TRANSACTIONS AND PROCEEDINGS

OF THE

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CONTENTS OF VOL. XXXII.

A LIST

OF

The Flowering Plants and Ferns

recorded from

Fife and Kinross (V.C.85)

BY

WILLIAM YOUNG

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INTRODUCTION.

Vice-county 85 of Watson's "Topographical Botany" comprises the counties of Fife and Kinross. On the east coast of Scotland, it is a peninsula bounded by the Firth of Forth on the south, the North Sea on the east, and the Firth of Tay on the north, while on the west it is bounded by the counties of Perth and Clackmannan. The greatest breadth is about 35 miles, and its extreme length about 40 miles; its superficial area is 570 square miles, or about 365,000 acres.

The vice-county is largely agricultural and has been increasingly so for many generations, resulting in the establishment of a large number of weeds of cultivation. On the south coast the presence of seaports engaged in the export of coal has led to the introduction of numerous aliens brought in the ballast of ships.

The natural drainage of the vice-county is from west to east, roughly parallel with the Firths of Forth and Tay. Of the rivers the largest is the Eden, which, rising in the Lomond Hills, flows eastward to the North Sea at St. Andrews. Farther south is the River Leven, draining the loch of the same name, and reaching the Firth of Forth at the town of Leven. Several lochs, the largest being Loch Leven, lying wholly in Kinross-shire, add considerably to the aquatic flora of the vice-county.

The greater part of the vice-county is low-lying, but several hills of considerable altitude add a small number of sub-alpine and even alpine plants to the county list. The highest hills are the East Lomond and West Lomond, rising to 1260 feet and 1713 feet respectively.

Considerable tracts of swampy, peaty land still remain, such as Moss Morran, near Cowdenbeath, and the Begg Moss, near Kirkcaldy, while Tents Muir on the coast in the extreme north-east is famous as the habitat of many rare plants. Sea cliffs occur at Kinkell near St. Andrews, at Kincraig to the west of Elie, and also between Kirkcaldy and Kinghorn.

In the course of two centuries or more many botanists have been at work collecting and recording. The majority of them did this work thoroughly in their own neighbourhood.

As already mentioned, many plants recorded have been introduced and many are garden escapes. In some cases these have become so well established that it is difficult to determine whether they are native or not. While there has been a great deal of recording, much of it is comparatively old, and in some places plants found fifty or more years ago have quite disappeared. Some of the critical genera, such as *Rosa*, *Rubus*, *Hieracium*, *Salix*, and *Carex*, have received but little attention, so future botanists have ample scope for intensive research work. The Cryptogamia have received some attention, and it is hoped to publish later the records for this division.

Since Sibbald, more than two centuries ago, published his "History of Fife," in which he gave a list of plants with the long descriptive names of the pre-Linnean period, many other lists have appeared from time to time in various publications, but no complete Flora of Fife and Kinross has yet been published. The Floras of Lightfoot (1777), Hooker (1821), and Greville (1824) all record some plants found in the county. The first substantial list appeared in Leighton and Swan's "Fife Illustrated," published in 1840. The "New Statistical Account of Scotland," issued 1835–44, contains lists of plants found in certain parishes, compiled by the ministers of these parishes. Ballingall's "Shores of Fife" (1872) includes a list of plants recorded by Charles Howie, who also contributed a similar list to Millar's "Fife: Pictorial and Historical" (1895). The Rev. James Campbell of Balmerino, the Rev. Walter Wood of Elie, and Dr. Alexander Laing of Bridge of Earn, in addition to describing the family histories of their own particular neighbourhood, gave lists of plants noted by them. Balfour and Sadler's "Flora of Edinburgh" (1863) and Sonntag's "Pocket Flora of Edinburgh" (1894) contain many records of Fifeshire plants. The late Sir Isaac Bayley Balfour in 1894 published in the Transactions of the Botanical Society of Edinburgh a list of plants gathered by the Rev. Alexander Robertson in the district around Inverkeithing a century ago. Sir Isaac also, in 1902, published the records of botanical excursions made by his father, Professor J. H. Balfour, along with his students in the years 1846–76. These two publications contain quite a mine of information regarding the habitats of rare plants many of which are now extinct. Certain

parts of the vice-county have received special attention. Robert and Dr. William G. Smith explored very exhaustively the northern part in connection with their Botanical Survey of Scotland, and many records stand to their credit. Similarly the flora of the eastern part has been very carefully investigated by the late Mr. George Sim of Crail and Dr. J. H. Wilson of St. Andrews. The western part was minutely examined by Dr. Dewar of Dunfermline, who was contemporary with the Rev. A. Robertson just referred to, and probably they worked together in that district. Mr. George West in his "Flora of Scottish Lakes," in the Proceedings of the Royal Society of Edinburgh (1910), made a large contribution to the records of aquatic plants in the vice-county. The herbarium of the late J. T. Boswell-Syme of Balmuto, which is now housed in the British Museum, probably contains many plants collected in Fife, as also that of Dr. Lauder Lindsay in the herbarium of Glasgow University, but so far there has been no opportunity of examining them.

The present Flora is an attempt to bring together in one publication all these records. A list of all the books consulted and the herbaria examined is appended. The nomenclature in many cases was entirely different from that now used, namely, the "London Catalogue of British Plants," 10th edition (1908). Many of the old records were based on specimens which do not now exist, so it has been impossible to verify them. The original intention was to visit the various localities with this object in view, but that has been unattainable. Inevitably there will have been errors of identification, but rather than omit doubtful records it has been thought advisable to include them so that future botanists may know what to look for in any particular district. For the above reasons those making use of this Flora should consider critically records of closely allied species shown as occurring in the same locality by different botanists.

For the purposes of this survey the vice-county has been divided into nine districts.

No. 1 begins at Newburgh, and includes all the high land draining into the Tay as far east as Tayport.

No. 2 embraces the valley of the Eden from its source in the Lomond Hills to St. Andrews, with Tents Muir and the Kinkell Cliffs.

No. 3 takes in all the land to the east of a line drawn from that point to Earlsferry. This corner is what is known as the "East Neuk of Fife."

No. 4 starts from Kincraig round by Largo and Leven Bays to Leven, including the landward portion behind draining into these bays through the Cocklemill and Kiel Burns.

No. 5 is the valley of the River Leven from its exit from the loch to its mouth.

No. 6 is the valley of the Ore from its source in the lochs to the north of Dunfermline to its confluence with the Leven at Cameron Bridge.

No. 7 commences at the town of Leven, continuing through Wemyss, Dysart, and Kirkcaldy to Kinghorn and Burntisland. The only streams of any importance in this area are the burn at the east end of Kirkcaldy and the Tiel Burn at the west end, near where it is augmented by the Dronachy Burn issuing from Camilla Loch and through Raith Lake.

No. 8 is a large district and was at one time the richest in plants. It extends westward along the coast from Burntisland to Aberdour, St. David's, Inverkeithing, North Queensferry, Dunfermline, Charlestown, Torryburn, Culross, and Kincardine to the boundary with Clackmannanshire, and northwards, including the Saline Hills, to the boundary of Kinross-shire.

No. 9 embraces the whole of the county of Kinross.

A map of the vice-county roughly delineating these districts is annexed.

In conclusion I desire gratefully to acknowledge the valuable help and encouragement I have received from many friends in preparing this Flora. In particular I am indebted to the late Sir Isaac Bayley Balfour and to his successor, Sir William Wright Smith, for facilities for examining the large collection of British plants in the Edinburgh Herbarium; to Col. H. Halcro Johnston, Orkney, for access to the herbarium of the late Mr. A. Craig Christie; to the late Councillor Mrs. Somerville for examining the herbarium of the late Mr. Alexander Somerville; to the late Mr. Arthur Bennett, Croydon, for lists of Fifeshire plants; to Mr. John Ritchie, Director of Perth Museum, for specimens and list of plants; to Professor R. J. D. Graham, St. Andrews, for the loan of notebooks compiled by his predecessor, Professor R. A.

Robertson, and others; to Professor J. R. Matthews, Aberdeen, for lists of plants; to the late Dr. W. G. Smith for lists of plants compiled by himself and his brother Robert; and to Mr. W. Edgar Evans for lists of plants in his father's and his own herbarium.

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Wm. W. Evans, Edinburgh (W.W.E.).
Wm. Evans, Edinburgh (W.E.).
W. Edgar Evans, Edinburgh (W.E.E.).
Royal Botanic Garden, Edinburgh (R.B.G.).
Robert H. Meldrum, Perth (R.H.M.).
Alexander Somerville, Glasgow (A.S.).
George Sim, Crail (G.S.).
J. Boswell Syme, Balmuto (J.B.S.).
Kirkcaldy Naturalists' Society (K.N.S.).
William Young, Kirkcaldy (W.Y.).

Collectors whose Plants are partly included in above.

G. A. Walker-Arnott, Kinross (W.A.).
Wm. Barclay, Perth (W.B.).
Dr. Dewar, Dunfermline (D.).
Col. Drummond-Hay, Perth (D.-H.).
Patrick Neill Fraser, Edinburgh (P.N.F.).
Charles Galloway, Balcarres, 1842 (C.G.).
Alex. H. Gibson, Kirkcaldy (A.H.G.).
F. J. Hanbury, London (F.J.H.).
Charles Howie, St. Andrews (C.H.).
W. Lauder Lindsay, Perth (W.L.L.).
Jas. M'Andrew, Edinburgh (J.M'A.).
A. Templeman, London (A.T.).
H. C. Watson (H.C.W.).
F. M. Webb, Edinburgh (F.M.W.).
F. Buchanan White, Perth (B.W.).

DICOTYLEDONS.

RANUNCULACEAE.

Clematis Linn.

C. Vitalba L. (*Traveller's Joy*)
Doubtful native. Woods and hedges on calcareous soil.
(7) Burntisland Binn (J. H. B., 1863); between Kinghorn and Burntisland (W. E. E., 1907); (8) Aberdour.
First Record: Aberdour, Aug. 1837 (R. B. G.).

Thalictrum Linn.

T. dunense Dum. (*Sand-dune Meadow-rue*)
Sandy and stony seashores. Frequent on S. coast.
(2), (3), (4) Lundin Links (A. S.), (7), (8).
First record: Arnott and Greville, coast west of Kirkcaldy.

T. minus L. (*Small Meadow-rue*)
Rare. Probably confused with *T. dunense* Dum. and *T. majus* Crantz.
(2) St. Andrews (J. H. W.); (3) Caiplie (G. S.); (4) Elie and Largo (J. H. B.); Kilconquhar (A. C. C.); (7) west of Kirkcaldy (H. C. W.); (8) Aberdour and N. Queensferry (H. C. W.).

T. majus Crantz (*T. flexuosum* R.)
Rare.
(3) Crail (Dr. Knapp, 1836); (8) N. Queensferry (J. H. B. and A. C. C.); Limekilns (R. S.); Aberdour (J. H. B.); near Aberdour Harbour (W. E. E.).
First record: Greville, Ferry Hills, 1824.

T. flavum L. (*Yellow Meadow-rue*)
Very rare. Banks of ditches and streams.
(7) Kinghorn (A. S.); (8) Donibristle (D., 1835) (J. H. B.); Inverkeithing (A. R.); Dunfermline (A. S.).
First record: Lightfoot, (8) N. Queensferry, leg. Dr. Parsons.

Anemone Linn.

A. nemorosa L. (*Wood Anemone*)
In woods. Abundant.
(1), (2), (3), (4), (5), (6), (7).
First record: Lightfoot, (7) "Bogie," near Kirkcaldy.

Adonis Linn.

A. annua L. (*A. autumnalis* L.) (*Pheasant's Eye*)
Colonist. Rare. In cornfields.
(8) Charlestown (A. C. C., 1872).
First record: St. David's, 1837 (Millar).

A. aestivalis L.
Alien.
Waste ground at (8) Charlestown (W. E. E., 1906).

Ranunculus Linn.

R. circinatus Sibth.
Rare.
(1) Lindores Loch (A. L.); Lochmill Loch (G. W.); (4) Kilconquhar Loch (G. W.); (8) Otterston Loch (G. W.).
First record: Balfour and Sadler, Otterston Loch, 1863.

R. fluitans Lam.
Very rare. Streams.
(7) Near Kinghorn (B. and S., 1863). Only record.

R. trichophyllus Chaix (*Water Fennel*)
Rare.
(7) Kinghorn Loch (R.B.G., J.S.).
First record: B. and S., Dunfermline, 1863.

R. Drouetii F. Schultz
Ponds and ditches. Rare.
(3) Crail's Muir Quarry (G. S., 1889); (6) Morton Loch (G. W.); (7) Kinghorn Loch (G. W.).

R. heterophyllus Weber (*R. aquatilis* Sm.)
Ponds and streams.
(1) Lindores Loch (A. L.); (2) Forgan Bog, near St. Fort, and Tents Muir (W. G. S. and R. S.); (7) Camilla Loch (W. Y.); (8) N. Queensferry (A. S.); (9) Loch Leven (R. S.).
First record: Dysart Woods (J. H. B., 1847).

R. peltatus Schrank
Wet places. Rare.
(1) Lindores and Lochmill Lochs (G. W.); (3) Pitcorthie (G. S., 1891); (6) Morton Loch (G. W.); (7) Kinghorn Loch (G.W.); (9) Lomond Hills.
First record: G. Sim, (3) Pitcorthie.

R. Baudotii Godr.
Rare.
(4) Kilconquhar Loch (G. W.); (6) Morton Loch (G. W.); (8) Otterston Loch (G. W.).

R. Lenormandi F. Schultz
Probably error for *R. hederaceus* L.
(7) Dunfermline (Sonn.). Only record.

R. hederaceus L.
Abundant everywhere.

R. sceleratus L.
Frequent in marshy places.

R. Flammula L. (*Lesser Spearwort*)
Common in wet places.
First record: (2) Monimail (L. and S., 1840).

var. b. **radicans** Nolte
(1) Lindores Loch (G. S., 1886); (9) Loch Leven (G. W.).

var. c. **natans** (Pers.)
(1) Morton Loch; (2) Tents Muir (G. W.)

R. reptans L.
Wet places. Not common.
(2) Tents Muir (B.); (4) Carriston Reservoir (G. W.); (5) Ballo Reservoir (W. Y., teste W. E. E., October 1936); Lomond Hills (J. H. B.); (6) Loch Fitty (B. and S.); (8) Inverkeithing; (9) Orwell parish (N.S.A.); Loch Leven (J. B. S.; J. H. B.).
First record: Lightfoot, at west end of Loch Leven (Dr. Parsons).

R. Lingua L. (*Great Spearwort*)
Marshes and ditches. Rare.
(1) Lindores Loch (G. S.); (4) Kilconquhar Loch (W.);

(8) Otterston Loch (B. and S.) and (G. W.); Saline parish; (9) Cleish Castle.

First record: Hooker, Powmill, Kinross (H. C. W.).

R. auricomus L. (*Goldilocks*)

Woods and thickets. Widely distributed.

(1) Birkhill, etc. (W. G. S.); (2) Monimail (L. and S.); Melville Woods, Collessie and Cults (N. S. A.); (5) Markinch (R. B. G.); (8) Inverkeithing (A. R.); N. Queensferry; Burntisland; (9) Cleish (N. S. A.).

R. acris L. (*Upright Crowfoot, Buttercup*)

Meadows and pastures. Very common.

R. repens L. (*Creeping Crowfoot*)

Meadows and pastures. Very common.

Fl. pl. recorded by Ballingall from Kinness Burn, St. Andrews (2).

R. bulbosus L. (*Bulbous Crowfoot*)

(1) Balmerino (W. G. S.); Scotscraig (R. S.); (2) Falkland (B. and S.); St. Andrews, Kinness Burn (J. H. W.); (3) Crail (G. S.); (4) Balcarres (C. G.); (5) banks of R. Leven (A. H. G.); (7) Kinghorn (W. Y.); (8) N. Queensferry (J. H. B.).

First record: J. H. Balfour, (7) Burntisland, 1855.

Fl. pl. recorded by Ballingall from Lundin Links (4).

R. sardous Crantz (*R. hirsutus* Curt.)

Waste land and cornfields. Local.

(2) By River Eden, Cults parish (N. S. A.); (7) Burntisland (F. W. W.); (8) Inverkeithing (B. and S.); Dunfermline (D.); St. David's (A. C. C.); Kincardine (J. H. B.).

First record: Dr. Knapp, (3) Crombie Point, 1837.

R. parviflorus L.

Cornfields and dry banks. Very rare.

(8) Charlestown (A. C. C. 1871). Only record.

R. arvensis L. (*Corn Crowfoot*)

Doubtful native.

(2) Near Cupar (leg. H. Matthews, 1890, Herb. A. S.); (3) Crail (G. S.); (4) Largo (W.); (7) Kinghorn (N. S. A.); (8) Charlestown (A. C. C.).

R. Ficaria L. (*Lesser Celandine*)
Common. Damp and rather shady places.

Caltha Linn.

C. palustris L. (*Marsh Marigold*)
Marshy places. Common.

[**C. radicans,** Forster
Recorded in N. S. A. from Cults parish (2), as "by no means uncommon on hills," but evidently in error.]

Trollius Linn.

T. europaeus L. (*Globe Flower*)
Damp places. Uncommon.

(2) Near St. Andrews (L. and S.; G. S.); Ballomill (N. S. A.); Mount Melville, in old pasture (B.); (4) Lathones (W.); (7) Glassmount Woods (J. H. B.); (8) Kinghorn parish (N. S. A.); Burntisland (B. and S.); near Dunfermline (J. H. B.); (9) Cleish parish (N. S. A.).

Helleborus Linn.

H. viridis L. (*Green Hellebore*)
Rare. Introduced. Thickets on calcareous soil.

(1) Lindores Abbey (A. L.) (G. S., 1891); near Scotscraig (W. G. S.); (3) Cambo, near Crail (G. S.).

H. foetidus L. (*Stinking Hellebore*)
Introduced. Thickets in chalky districts.

(3) Cambo Woods (J. H. W.); Caiplie near Anstruther (H. C. W.); Pitcorthie Woods (W.).

First record: Hooker—" between Anstruther and Caiplie, Mr. Chalmers."

Eranthis Salisb.

E. hyemalis Salisb. (*Winter Aconite*)
Naturalised in thickets. Rare.

(1) Balmerino Abbey (J. C.); (2) Melville; Monimail parish (N. S. A.); (3) Beech Walk, Crail (G. S., 1890); (7) Balmuto; (9) Cleish Castle (J. H. B., 1837, R.B.G.).

Aquilegia Linn.

A. vulgaris L. (*Columbine*)
Woods and thickets and heaths. Not common.

(1) Balmerino Abbey (J. C.); (2) near St. Andrews (J. H. B.);

(4) Balcarres Den (C. G.); (5) Whinnyhall Wood, 1846; (7) Dysart Woods (J. H. B.); Raith (J. H. B.); (8) N. Queensferry (J. H. B.); Pitreavie (Dr. Dewar); (9) Loch Leven Sluices (W. Y.).

First record: Whinnyhall Wood, near Leslie, 1846.

Delphinium Linn.

D. Ajacis L. (*Larkspur*)

(2) Near Ladybank Railway Station (J. Sadler, 1876, R.B.G.). Only record.

Aconitum Linn.

A. Napellus L. (*Monk's-hood*)

Casual.

(1) Balmerino Abbey (J. C.); (2) near St. Andrews (J. H. B.); banks of Moutray and Eden (M.; B.); (7) Dysart Woods (J. H. B. and W. Y.); Raith (R. B. G.); (8) near Fordel and Inverkeithing (A. R.); old building near Otterston Loch (W. E. E.).

First record: Inverkeithing, A. Robertson, 1834.

Actaea Linn.

A. spicata L. (*Bane-berry*)

Very rare.

(9) Cleish Castle, 1837 (K. N. S.), 1840 (R. B. G.), 1863 (B. and S.).

First record: Hooker, (9) Cleish Woods.

BERBERIDACEAE.

Berberis Linn.

B. vulgaris L. (*Barberry*)

Hedges and thickets. Alien.

(1) Lindores Loch (N. S. A., 1845) (A. L., 1876) (M., 1895); (2) Edenshead (L. and S.); (3) roadside between Pitcorthie and Balcaskie (W.); Crail (W. Y.); (4) Kiel's Den (B.); Kilconquhar (B. and S.); (7) Dysart Woods and Raith (J. H. B.); Begg Farm (R. B. G.); (8) Burntisland (B. and S.); Aberdour (J. H. B.); near Otterston Loch (W. E. E.);

N. Queensferry (J. H. B.); Charlestown (B. and S.); Pitreavie (D. and A. C. C.).

First record: (8) Pitreavie, Dewar, 1836.

Epimedium Linn.

E. alpinum L. (*Barrenwort*)

Introduced.

(8) Near Saline (J. H. B.); Inverkeithing (B. and S.); (9) Cleish (W. A.).

First record: near Inverkeithing, A. Robertson, 1836.

NYMPHAEACEAE.

Nymphaea Linn.

N. lutea L. (*Yellow Water-Lily*)

Lochs, ponds, and streams. Frequent.

(1), (2), (3), (4), (6), (7), (8), (9).

First record: Dr. Dewar, Dunfermline, 1836.

var. b. **intermedia** (Ledeb.)

(9) Black Loch, Cleish (A. T., 1919, and G. W.).

Castalia Salisb.

C. alba Wood (*C. speciosa* Salisb.) (*White Water-Lily*)

(1) Lindores Loch (W. G.); Black Loch (J. H. B., and L. and S.); Loch Mill (J. H. B.); (6) Loch Gelly (G. W.); (7) Raith Lake (W. Y.); Kinghorn Loch (J. H. B.); (8) Hillhead Loch (Dewar); (9) Loch Leven.

First record: Sibbald, no locality.

var. **minor**

(8) Black Loch near Dunfermline (A. T., 1919).

PAPAVERACEAE.

Papaver Linn. (*Poppy*)

P. somniferum L.

Casual.

(1) Lindores Abbey (L. and S.); Newburgh (N. S. A.); (3) road between Anstruther and St. Andrews, Dr. Knapp,

1836 (R.B.G.); (7) Raith (J. H. B.); (8) St. David's and Inchcolm (A. C. C.); N. Queensferry and Donibristle (B. and S.); (9) Kinross (B. and S.).

First record: Dr. Knapp, (3) near Anstruther, 1836.

P. Rhoeas L. (*Corn Rose*)

In arable fields. Very common.

First record: Dr. Dewar, near Kirkcaldy, 1837.

P. dubium L.

Common.

First record: J. H. Balfour, 1850.

P. Lecoqii Lamotte

Rare.

(3) Crail (C. C. Babington, 1887); Burntisland (Boswell-Syme, 1871, R.B.G.).

P. Argemone L.

Frequent.

(1), (2), (3), (4), (7), (8), (9).

First record: Professor J. H. Balfour, near Charlestown (1848).

P. hybridum L.

Sandy fields. Very rare.

(8) St. David's (A. C. C., 1880). Only record.

Meconopsis Vig.

M. cambrica Vig. (*Welsh Poppy*)

Damp rocky and shady places. Rare.

(7) Auchtertool (J. H. B.); Balmuto (A. C. C.); (8) Burntisland (J. H. B., R.B.G.); (9) Cleish Castle (A. R.).

First record: Alex. Robertson, Cleish, 1839.

Glaucium Hill

G. flavum Crantz (*G. luteum* Scop.) (*Horned Poppy*)

Sandy seashores. Rare.

(2) Tents Muir (B.); (3) east of Anstruther (Greville, R.B.G.) (Dr. Graham, R.B.G., 1830); (4) near Elie (W. Y.); Kincraig (J. B. Duncan); Kilconquhar (A. S.); (8) St. David's (K. N. S., 1836); near Charlestown (J. H. B.); Dunfermline parish (N. S. A.).

First record: Lightfoot, Charlestown Lime Works.

Chelidonium Linn.

C. majus L. (*Celandine*)

Waste places and old walls. Doubtful native.

(1) Near Newburgh; Gauldry (J. C.); (2) Cupar (J. H. B.); St. Andrews (M.); Falkland (B. and S.); (4) Temple, near Largo (A. C. C.); Lundin Links (A. S.); Charlestown (W.); (5) near Markinch (W. Y.); (6) Kennoway (B.); (8) Carnock (B.); near Limekilns (J. H. B.); Culross (N. S. A.); (9) near Loch Leven (J. H. B.).

First record: Carnock (N. S. A.).

FUMARIACEAE.

Corydalis Vent.

C. lutea DC. (*Yellow Fumitory*)

Naturalised on old walls. Rare.

(3) Dunino and Crail (G. S.); (7) Raith (B. and S.); (8) Inverkeithing (B.); Donibristle (K. N. S., 1836).

First record: Ballingall, Inverkeithing, 1830.

C. claviculata DC. (*White Climbing Fumitory*)

(3) Crail (W.); (6) Cowdenbeath (P. N. Fraser, 1858; A. S.); (8) Aberdour (B. and S.); Donibristle; Inverkeithing; Carnock Moor (N. S. A.); near Torryburn (J. H. B.); Culross (A. R.).

First record: A. Robertson, Culross, 1834.

Fumaria Linn.

F. capreolata L. (*F. pallidiflora* Jord.)

Borders of fields. Occurrence uncertain. Probably confused with *F. Boraei* Jord.

(1) Newburgh (A. L.); Balmerino (J. C.); (3) near Elie (J. H. B.); (4) near Colinsburgh (C. G.); (7) Kinghorn (N. S. A.); Burntisland (B. and S.); (8) Aberdour (B. and S.); St. David's (K. N. S., 1836, and A. C. C.); N. Queensferry (R. B. G.); Pitreavie (R. S.); (9) Orwell parish (N. S. A.).

First record: North Queensferry, 1831 (R. B. G.).

F. purpurea Pugsley

(7) Near Kirkcaldy (Druce)

F. Boraei Jord.
Common, see *F. capreolata* L. above.
(3) Crail (G. S.); (7) Auchtertool, Balwearie, S. of Dunearn Hill, Seafield (all J. B. S., Herb. Brit. Mus.); Linhead, Balmuto (J. B. S., 1874, R.B.G.).

var. **britannica** Pugsley
(7) Innerleven (Druce, 1912, Hb. Br. Mus.)

F. Bastardi Bor. (*F. confusa* Jord.)
(7) Balmuto (R. B. G., 1876); Kirkcaldy (1869, Hb. Boswell); Balwearie (J. B. S., Herb. Brit. Mus.).

F. officinalis L. (*Common Fumitory*)
Abundant throughout the county.

F. densiflora DC. (*F. micrantha* Lag.)
(1) Tayport, on ballast heaps (G. Law); (2) Falkland (B. and S.); Tents Muir and St. Andrews (J. H. B.); (3) Ardross (W.); (4) near Elie (J. H. B.); (7) Dysart Woods (J. H. B.); Auchtertool, Balmuto (J. B. S., Herb. Brit. Mus.); (8) Inverkeithing and N. Queensferry (B. and S.); (9) Loch Leven (J. H. B.); Lomond Hills and Rumbling Bridge (J. H. B.).
First record: J. H. Balfour, Dysart Woods, 1847.

F. parviflora Lam.
(3) East Neuk (W.); (8) St. David's, 1837 (doubtful).

CRUCIFERAE.

Cheiranthus Linn.

C. Cheiri L. (*Wallflower*)
Old walls. Frequent.
(1), (2), (3), (5), (7), (8), (9).

Radicula Hill

R. Nasturtium-aquaticum Ren. et Britt. (*Water Cress*)
Ditches and Streams. Common.
(1), (2), (3), (4), (5), (6), (7), (8), (9).
First record: 1845, New Statistical Account.

R. sylvestris Druce
Uncommon.
(7) Kirkcaldy (W. Y.); (8) Inverkeithing (K. N. S.); Bon-

hard (N. S. A.); Carnock (Dr. Dewar); Dunfermline parish (N. S. A.); (9) near Loch Leven.

First record: A. Robertson, near Loch Leven, 1835 (R.B.G.).

R. palustris Moench (*N. terrestre* Sm.)

Native. Not common. Marshes and borders of lochs and ponds.

(1) Balmerino (J. C.); (2) Tents Muir; (3) Crail (W. Y.); Kirkcaldy (G. S.); Kinghorn Loch (J. H. B.); (8) St. David's (K. N. S.); Charlestown (A. C. C.); Dunfermline (P. C.); Culross (B. and S.); (9) Loch Leven (Dr. Wight, 1832) (Druce, 1912, Trans. Bot. Soc. Edin., as *R. islandica* (Oeder) Druce); Orwell parish (N. S. A.).

First record: Kinghorn Loch, Greville (leg. Neill).

[**R. amphibia** Druce (*Armoracia amphibia* Koch)

Probably an error.

(7) Kinghorn (B. and S.); Burntisland Binn (J. H. B.)]

Barbarea Br.

B. vulgaris Ait. (*Yellow Rocket*)

Common throughout the county.

First record: Cults parish (N. S. A., 1845).

B. intermedia Bor.

Very rare.

(2) Near Ceres (C. Howie, May 1894, R.B.G.)

B. verna Aschers. (*B. praecox* Br.)

(3) Crail, as casual (G. S.); (8) Inverkeithing (A. R.).

Arabis Linn.

[**A. petraea** Lam.

Is recorded by Dr. J. H. Wilson as from (4) Kincraig Hill, but gives no collector's name or source of his information. It is scarcely possible to have occurred at this low elevation.]

[**A. ciliata** Br. var. b. **hispida** Syme

(4) Kilconquhar (L. and S., 1840); Kincraig (N. S. A.).

Both records doubtless refer to *A. hirsuta* L.]

A. hirsuta Scop.

Common throughout the county.

First record: Balfour and Sadler, Pettycur, 1863.

A. Turrita L.
Naturalised.
(9) Cleish Castle (W. C. Trevelyan, 1839, R.B.G.). Now extinct.

Cardamine Linn.

C. amara L. (*Common Bitter Cress*)
(2) Lomond Hills (J. H. B.); Falkland (B. and S.); (5) banks of River Leven (W.); (7) Raith (J. H. B. and W. Y.); Kinghorn parish (N. S. A.); (8) Inchcolm (Dr. Graham); Dunfermline (B. and S.); (9) Cleish (A. R.); Rumbling Bridge (J. H. B.)
First record: Cleish parish (N. S. A., 1845).

C. pratensis L. (*Lady's Smock, Cuckoo Flower*)
Common everywhere.
First record: Near Falkland (L. and S., 1840).

C. hirsuta L.
Common everywhere.

C. flexuosa With. (*C. sylvatica* Link)
Rare.
(1) Wormit (W. G. S.); (3) Dunino (G. S.); (7) Kirkcaldy (W. Y.); Burntisland (B. and S.); (8) Rosyth Woods (R. B. G.).
First record: Rosyth Woods (R. B. G., 1849).

C. impatiens L.
(2) Near Falkland (L. and S.), "doubtful record"; (7) Burntisland (B. and S.).

Alyssum Linn.

A. incanum L.
Casual.
(7) Near an empty house, west end of Burntisland Docks (W. E. E., 1903).

A. alyssoides L. (*A. calycinum* L.)
Uncommon.
(2) Near St. Andrews (J. H. B., 1867) (G. S.); (3) near Elie (J. H. B.); (4) Newburn parish; (7) Pettycur (R. B. G.); Kinghorn (A. C. C.); Balmuto (W. Y.); Burntisland Links

(R. B. G., 1853) (J. H. B. and A. C. C.); (8) N. Queensferry (R. B. G.); (9) shores of Loch Leven (B. and S.).

First record: Ferry Hills, J. H. Balfour, 1851.

A. maritimum Lam.

Casual. Naturalised on seashores.

(3) Elie (B. and S., 1863); Earlsferry Sands (W., 1887); (7) Pettycur (A. S., 1894); (8) St. David's, on ballast hills (B. and S., 1863) and (A. C. C., 1879).

Draba Linn.

D. muralis L. (*Whitlow Grass*)

(1) Tayport (M.); Ferryport (B.); (3) Crail—"casual" (G. S., 1889); Elie Harbour (B., 1872); (7) Raith (J. H. B.).

Erophila DC.

E. verna E. Meyer (*Vernal Whitlow Grass*)

Common on walls, banks, etc.

First record: N. Queensferry, 1835 (R. B. G.).

E. praecox DC.

Recorded for the county by Professor Trail in Annals Scot. Nat. Hist., 1898, without locality.

Cochlearia Linn.

C. officinalis L. (*Scurvy-grass*)

Common round the coast.

First record: Sibbald, Inchcolm, as *C. folio sinuato*.

C. danica L.

Seacoast. Frequent.

(2), (3), (4), (7), (8).

First record: Greville, Burntisland, leg. Maughan.

C. anglica L.

Rare.

(1) Balmerino (N. S. A. and J. C.); (4) Kincraig Point (W.); (7) Kinghorn (A. S.); (8) Inchcolm and N. Queensferry (A. S.).

First record: Leighton and Swan, 1840.

C. Armoracia L. (*Horse-radish*)

Waste ground. Casual or escape.

(2) Eden estuary (W.); (3) near Elie (J. H. B.); (7) Kinghorn (B. and S.).

Hesperis Linn.

H. matronalis L. (*Dame's Violet*)

Pastures. Introduced. Rare.

(2) Cupar (J. H. B.); (3) Elie (W. E., 1904); (7) near Kinghorn (J. H. B.); (8) Inverkeithing, Dunfermline, and Charlestown (A. R.); St. David's (W. Y.).

[**Malcolmia maritima** R.Br. is not a native, but recorded from Seafield, near Kirkcaldy (1846), and near Elie (1877), by Professor J. H. Balfour. Has been extinct for many years.]

Sisymbrium Linn.

S. Thalianum Gay (*Hedge Mustard*)

Common throughout the county.

First record: (8) Inverkeithing, A. Robertson, *c.* 1835.

S. officinale Scop.

Very common everywhere.

var. **leiocarpum** DC.

(8) Inverkeithing (1907, W. E. E.).

S. pannonicum Jacq.

Alien.

(7) Near Sandpits, Pettycur; and (8) St. David's Bay (W. E. E., 1906).

S. Sophia L. (*Flixweed*)

Waste places. Rare.

(1) Newport (W. G. S., 1886); (2) Tents Muir (Howie), near Guardbridge (D. H.); (3) St. Monans (J. H. B., 1864); (7) Burntisland Docks (W. E. E., 1902); (8) St. David's (A. C. C., 1867); Inverkeithing (B. and S., 1863); Charlestown (A. C. C.).

First record: Sibbald; no locality.

S. Irio L. (*London Rocket*)

Introduced.

(3) Elie Harbour (W.); (8) Charlestown (A. C. C., 1870).

S. Alliaria Scop. (*Alliaria officinalis* Andrz.) (*Jack-by-the-Hedge*)

Hedge-banks. Common everywhere.

S. polyceratium L.

Alien.

(8) Charlestown (A. C. C., 1871).

S. orientale L.
Alien.
(7) Shore at Kirkcaldy (W. E. E., June 1906).

Erysimum Linn.

E. cheiranthoides L. (*Worm-seed*)
Casual in cultivated ground. Very rare.
(8) West of Burntisland (J. H. B.); Charlestown (K. N. S., 1844).

E. orientale Mill. (*E. perfoliatum* Crantz)
Casual. Introduced.
(3) Crail (G. S.); (7) shore at Kirkcaldy, 1906, and near Kinghorn, 1903 (W. E. E.); Burntisland (A. C. C., 1888); (8) N. Queensferry (J. H. B., 1860).

Camelina Crantz

C. sativa Crantz (*Gold-of-pleasure*)
In fields. Introduced but not naturalised.
(2) Collessie parish (N. S. A.); (3) Elie (G. S.); (8) Aberdour Woods (J. H. B.); St. David's (Wallich, 1834, R.B.G.); Inverkeithing (A. C. C.); Charlestown (A. C. C.); Culross (A. R., Trans. Bot. Soc. Edin.); (9) Kinross Railway Siding (W. Evans).

var. b. **foetida** (Fr.)
(8) St. David's (J. H. B., 1871); Inverkeithing, Dunfermline, Charlestown (B. and S.).

Subularia Linn.

S. aquatica L. (*Awlwort*)
Native. Gravelly margins of lochs. Very rare.
(8) Otterston Loch (Maughan); (9) Orwell parish by Loch Leven (N. S. A.); Loch Leven (A. S., 1894).
First record: Greville, (8) Otterston Loch. "I fear this station may be erroneous" (Grev.).

Brassica Linn.

B. oleracea L. (*Wild Cabbage*)
Doubtful native. Rare. Sea-cliffs.
(3) Crail Harbour (G. S. and N. S. A.); (7) Dysart (B. and S.); Wemyss Castle rocks (W. E., 1868); Burntisland

(R. B. G.); Inchkeith (R. B. G.); (8) Inchcolm (B. and S.); St. David's (K. N. S., 1837); Charlestown (A. S.); N. Queensferry (J. H. B.).

First record: Hooker, Inchkeith, leg. G. Don.

B. Napus L. (*B. campestris* L.)

Fields and river-banks. Frequent.

(1), (2), (3), (4), (7), (8).

B. Rapa L. (*B. campestris* L.) (*Turnip*)

(3) Near Elie Pier, "probably imported" (W.); (7) near Wemyss (J. H. B., 1855); Inchkeith (R. B. G.); (8) Aberdour and N. Queensferry (B. and S.).

First record: Inchcolm, A. Robertson, 1834.

B. nigra Koch (*B. Sinapioides* Roth, *Sinapis nigra* L.)

(3) Near Elie (J. H. B.); (4) Balcarres (C. G.); (7) Burntisland Docks (W. E. E.); Inchkeith (R. B. G.); (8) Inchcolm and St. David's (J. H. B.); Inverkeithing (A. R.).

First record: Inchkeith, R. Maughan, 1831.

B. arvensis O. Kuntze (*B. Sinapistrum* Boiss.) (*Charlock*)

Cornfields. Common everywhere.

First record: Ferry Hills, 1836 (K. N. S.).

B. alba Boiss. (*White Mustard*)

Cultivated fields and waste land. An alien.

(2) Cults parish (N. S. A.); (3) near Crail (G. S.); Ardross (W.); (7) Kirkcaldy (B. and S.); Burntisland (K. N. S.); (8) St. David's (A. R.); near Dunfermline (K. N. S.); near Charlestown (J. H. B.).

First record: Burntisland, 1836 (K. N. S.).

B. dissecta Boiss.

Alien.

(7) Burntisland Docks (W. E. E., Aug. 1907).

B. elongata Ehrh.

Alien.

(7) Burntisland Docks (W. E. E., Sept. 1907).

B. juncea Coss.

Alien.

(7) Burntisland Docks (W. E. E., Aug. 1907).

Diplotaxis DC.

D. tenuifolia DC. (*Wall Mustard*)
Old walls. Introduced.
(1) Tayport and Ferryport (ballast heaps, B.); (3) Elie (B. and S.) (W.); (4) Kincraig (N. S. A.); Largo (J. H. B.); Pettycur (W. E. E., 1906); (8) St. David's, Inverkeithing (R. S.); west of Burntisland (Grev.); Limekilns (F. C. C.).
First record: Hooker, St. David's, leg. Neill.

D. muralis DC. (*Sand Rocket*)
Waste ground. Introduced.
(3) Elie Harbour (J. W. Brown, R.B.G.); (7) Burntisland Docks (W. E. E., 1902); (8) Inverkeithing (A. R., 1834); St. David's (A. C. C.); Charlestown (D., 1834, R.B.G.); Dunfermline parish (N. S. A.).

var. b. **Babingtonii** Syme
(4) Dysart (A. H. G., 1882, R.B.G.); (7) Burntisland (F. M. W., 1878, R.B.G., and W. E. E., 1902); (8) ballast heaps near Charlestown (J. K., 1837, R.B.G.).

Eruca Mill.

E. sativa Mill.
Alien.
Waste ground; (8) Charlestown (W. E. E., Nov. 1902).

Capsella Medic.

C. Bursa-pastoris Medic. (*Shepherd's Purse*)
Common everywhere.
First record: Burntisland, 1848 (R. B. G.).

Coronopus Hall.

C. didymus Sm. (*Senebiera pinnatifida* DC.)
Waste ground near the sea. Doubtful native.
(3) Near Elie (J. H. B. and W.); (7) Burntisland (B. and S.); (8) St. David's (1868); and Charlestown (1870, A. C. C.).
First record: Balfour and Sadler, Burntisland, 1863.

C. procumbens Gilib. (*Senebiera Coronopus* Poir.) (*Swine's Cress*)
Waste places. Rare. Doubtful native.
(3) Crail (W. Y.); St. Monans (H. Coates); Elie Harbour

(J. H. B.); (7) Pettycur (Arnott, R.B.G.); Burntisland (Hook.); (8) St. David's (A. R., R.B.G.) (A. C. C.); Inverkeithing (B.); N. Queensferry (A. D. Richardson, R.B.G.); Limekilns (I. B. B., R.B.G.).

First record: Greville, Burntisland, leg. Maughan as *C. Ruellii.*

Lepidium Linn.

L. latifolium L. (*Dittander*)

Salt marshes. Probably introduced. Rare.

(1) Balmerino (J. C.); (7) Wemyss Castle (Lightfoot) (W. W. Evans, 1840) (A. H. G., 1882, R.B.G.); Burntisland (A. C. C.); Dalgety (A. R., 1832, and B. and S., 1863); near Inverkeithing (B.); Culross (A. R., Trans. Bot. Soc. Edin.); (9) Kinross (A. R., Trans. Bot. Soc. Edin.).

First record: Lightfoot, (7) Wemyss Castle.

L. ruderale L.

Waste places near the sea. Introduced. Very rare.

(1) Tayport (C. H.); (3) Elie Harbour (W.); between Anstruther and Elie (J. H. B., 1864); (8) St. David's (D., R.B.G.); Inverkeithing (Miss Robertson, 1860, R.B.G.); Charlestown (B. and S.) (A. C. C., 1872).

First record: A. Robertson, St. David's, 1835.

Sonntag says it is "frequent in villages."

L. sativum L.

Waste places. Casual.

Sonntag records as "from Inverkeithing—introduced."

L. campestre Br. (*Pepperwort*)

Dry gravelly soil. Not common.

(1) Balmerino (J. C.); (3) Crail (G. S.); (7) Kirkcaldy (W. Y.); Pettycur (B. and S.); Burntisland (J. H. B.); (8) near Starleyburn (R. B. G.); Aberdour (J. H. B.); Inverkeithing (B.); (9) Orwell parish (N. S. A.).

L. heterophyllum Benth. var. b. **canescens** (Gren. et Godr.) (*L. Smithii* Hook.)

(1) Wormit (G. S.); (2) near Cupar (J. H. B.); Lucklaw Hill (B.); (7) near Wemyss (J. H. B.); Kinghorn (Fraser, 1904); Burntisland (J. H. B.); (8) St. David's (A. C. C.); near Torryburn (J. H. B.); Culross, Saline Hill (J. H. B.);

(9) Orwell parish (N. S. A.); railway siding, Kinross (W. E. E., 1903).

First record: Balfour and Sadler, Culross, 1863.

L. Draba L. (*Pepperwort*)

Established but not naturalised.

(3) Crail (G. S.); (6) Thornton (G. S.); (7) Kirkcaldy (W. Y.); Burntisland (J. H. B.) (A. C. C.) (A. H. G.); (8) Aberdour (J. H. B.).

First record: near Burntisland, J. H. Balfour, 1868.

Thlaspi Linn.

T. arvense L. (*Penny Cress*)

Fields and roadsides. Widely distributed. Colonist only. (2), (3), (4), (7), (8), (9).

Iberis Linn.

I. amara L. (*Candytuft*)

Alien. Very rare.

(2) Sandy bank near the sea between St. Andrews and Guardbridge (D.-H., 1871); (3) Elie (A. C. C., 1872); (7) Kirkcaldy (B. and S., 1863) (W. E. E., 1906); (8) Inchcolm (J. Knapp, R.B.G.) (B. and S.); N. Queensferry (B. and S.); Charlestown (Trans. Bot. Soc. Edin.).

Teesdalia Br.

T. nudicaulis Br.

Sandy and gravelly places.

(1) Balmerino (J. C., R. S.), Tayport; (2) Tents Muir (W. Y.); St. Andrews Links (G. S., with J. H. B., 1867); Lucklaw Hill and Edenside (M., 1895); Leuchars (W. Barclay) (J. H. B.).

Isatis Linn.

I. tinctoria L. (*Woad*)

Professor J. H. Balfour gives "Fife."

Casual. Recorded by Professor Trail (1905) as occurring, but no locality given. Sibbald records it from Inchcolm as *Isatis sive glastum*.

Bunias Linn.

B. orientalis L.

Alien.

(9) Railway siding, Loch Leven Station (W. E. E., 1903).

Crambe Linn.

C. maritima L. (*Sea-kale*)
Sandy seashores. Very rare.
(3) Kincraig (G. S.); near Elie (J. H. B.) (W. E. E., 1903 and 1907); Kilconquhar (B. and S.); (4) Largo (B.) (now extinct); (8) Inchcolm (A. R., Trans. Bot. Soc. Edin.); Port Laing (1836).
First record: Sibbald; no locality.

Cakile Mill.

C. maritima Scop. (*Sea Rocket*)
Sandy seashores. Frequent.
(2), (3), (4), (7), (8).
First record: Lightfoot, "at Kirkaldy" as *Bunias cakile.*

Raphanus Linn.

R. Raphanistrum L. (*Jointed Charlock*)
Cornfields. Colonist.
(1) Near Newburgh (albino, Dr. B. W.); Wormit (W. G. S.); Balmerino (J. C.); (2) near St. Andrews (W. G. S.); Falkland (B. and S.); (3) East Neuk (W.); Elie (J. H. B.); (7) Dysart (B. and S.); (8) N. Queensferry (B. and S.)

R. maritimus Sm. (*Sea Radish*)
Seacoast. Rather doubtful.
(3) Near Elie (M., 1895).

RESEDACEAE.

Reseda Linn.

R. alba L. (*R. suffruticulosa* L.)
Sandy places near the sea. Casual.
(3) Crail (G. S., 1889); (8) Inverkeithing (Sonn.).

R. lutea L. (*Mignonette*)
Waste rocky places. Very local.
(1) Newburgh (A. L.); Balmerino (J. C.); (2) Ballomill, Collessie parish (N. S. A.); (3) near Elie (J. H. B.); (4) Dunbarnie Links and Leven (B., and M.); (7) Kirkcaldy (W. Y.); Pettycur (Maughan, 1815); Burntisland (F. C. C. and J. H. B.); (8) St. David's (J. H. B.); Inverkeithing and

Limekilns (A. R., Trans. Bot. Soc. Edin.); Charlestown (J. H. B.).

First record: Lightfoot, "Links of Kirkcaldy" (leg. D. Don).

R. Luteola L. (*Dyer's Weed*)

Waste places or limestone rocks. Frequent.

(1), (2), (3), (4), (7), (8).

First record: Lightfoot, Dysart and Burntisland.

CISTACEAE.

Helianthemum Mill.

H. Chamaecistus Mill. (*H. vulgare* Gaertn.) (*Rock-rose*)

Dry hilly places. Common.

(1), (2), (3), (4), (7), (8), (9).

VIOLACEAE.

Viola Linn.

V. palustris L. (*Marsh Violet*)

Wet places. Rather rare.

(1) Forgan Bog (R. S.); (2) Tents Muir (R. S.); (5) Markinch (A. C. C.); (7) Balmuto (W. Y.); (8) to east of Dalgety Church (Trans. Bot. Soc. Edin., A. R.); Inverkeithing (A. R.); Pitreavie (R. S.); Torryburn (J. H. B.); (9) Cleish parish (N. S. A.); Lomonds (B. and S.).

V. odorata L. (*Sweet Violet*)

Frequent.

(1), (2), (4), (6), (7), (8).

V. hirta L. (*Hairy Violet*)

Uncommon.

(1) Balmerino (J. C.); (7) Raith (J. H. B.); near Auchtertool (W. Y.); Balmuto (Miss Boswell); Orrock Hill (B. S.); (8) Aberdour (A. C. C.); Donibristle (R. B. G.); St. David's (A. C. C.); Inverkeithing and N. Queensferry (B. and S.); Dunfermline parish (N. S. A.); near Limekilns (Trans. Bot. Soc. Edin.); Charlestown (J. H. B.).

First record: Greville, "bank near toll N. Ferry, leg. Neill."

V. sylvestris Kit. (*V. Reichenbachiana* Bor.)
Hedge-banks and thickets. Rare.
(7) Burntisland (J. H. B., 1856).

V. Riviniana Reichb. (*Wood Violet*)
Hedge-banks, thickets, and heaths. Common.
First record: Crail, G. Sim, May 1889.

V. canina L. (*Dog Violet*)
Sandy and peaty places. Common.
First record: J. Knapp, Lomond Hills, 1834 (R.B.G.).

V. flavicornis Sm.
"A small form of above with cordate leaves" (Babington). Recorded by Boswell Syme (May 1872) from (7) side of burn above Auchtertool Linn and also from West Toricis Park, Balmuto.

V. arvensis Murr. (*V. tricolor* L.) (*Heartsease, Pansy*)
Pastures and banks. Frequent.
First record: J. Knapp, (1) near Newport, 1835.

var. **agrestis** Jord.
(9) Kinross (J. R. M., 1922).
forma **segetalis** Jord.
(9) near Milnathort (J. R. M., 1922).

var. **obtusifolia** Jord.
(9) Kinross (J. R. M., 1922).

var. **ruralis** Jord.
(8) near Kinghorn (J. R. M.).
forma **derelicta** Jord.
(8) near Kinghorn (J. R. M.).

var. **Lloydii** Jord.
(9) Kinross (J. R. M.).

V. Curtisii Forster
(5) Near Leslie (G. S., 1907). Doubtful.

V. lutea Huds. (*Yellow Mountain Violet*)
Hill pastures. Frequent.
First record: Sibbald, as *V. grandiflora*; no locality.
forma **amoena** Symons
(9) East Lomond, G. Sim, Crail (1863). Only record.

POLYGALACEAE.

Polygala Linn.

P. vulgaris L. (*Milk-wort*)
Dry pastures. Common.
First record: (8) North Queensferry (R. B. G., 1831).

P. serpyllacea Weihe
(8) Aberdour, July 1877, leg. D. Douglas, Leith, labelled *P. depressa.* It is certified by Dr. Boswell as "a form approaching *P. oxyptera.*" Specimen is in herbarium of Royal Botanic Garden, Edinburgh.

CARYOPHYLLACEAE.

Dianthus Linn.

D. deltoides L. (*Maiden Pink*)
Hilly pastures. Rare.
(1) Newburgh (G. Don) and (J. H. B.); Mare's Craig (A. L.); Scotscraig (R. S.); near Tayport (G. Law); (2) Monimail (L. and S.); Leuchars (R. S.); (4) Largo Law (W. Y.); (5) Kennoway (B. and S.); (7) Orrock Hill (J. B. S.); Dunearn Hill (N. S. A.); (9) Lomond and Ochil Hills (B. and S.).
First record: Hooker, Newburgh.

D. Caryophyllus L. (*Clove Pink*)
Naturalised.
(7) Burntisland Station (W. E. E., Sept. 1907); (8) Monastery, Inchcolm (A. R., Trans. Bot. Soc. Edin.) (K. N. S., 1838); Inchgarvie (Dr. Dewar, 1837, R.B.G.).

D. barbatus L.
Probably a garden escape.
Recorded by Millar from shore at (8) Aberdour, July 1835, and by J. H. Balfour from (9) Rumbling Bridge, July 1863.

Saponaria Linn.

S. officinalis L. (*Soapwort*)
Introduced. Woods and waste bushy places. Very rare.
(1) Pitcairly (A. L.); (7) Burntisland (Neill); (8) St. David's (R. B. G.); Inverkeithing (Fraser) (K. N. S., 1836) (W. E. E.,

1907); Charlestown (J. H. B.); (9) Cleish parish (N. S. A.).
First record: Greville, Burntisland, leg. Neill.

var. b. **puberula** Wierzb.
(8) Behind foundry, Inverkeithing (W. L. L., Aug. 1849).

S. Vaccaria L.
Alien.
Waste ground, (8) St. David's (W. E. E., July 1906).

Silene Linn.

S. latifolia Rend. et Britt. (*S. Cucubalus* Wibel) (*Bladder Campion*)
Fields and roadsides. Common.
(1), (2), (3), (4), (7), (8).

var. **puberula** Jord.
(1) Near Newburgh (B. W., 1876, and A. L.); (2) East Sands, St. Andrews (D.-H.); (3) East Neuk (W.); (4) Lundin Links (A. H. G., 1883, R.B.G.).

S. maritima With. (*Sea Campion*)
Near the sea. Frequent.
(1), (2), (3), (4), (7), (8).
First record: Greville, Pettycur, etc. as "*Silene inflata* var. *amoena*," Lightfoot.

S. Armeria L.
Alien.
(1) By railway track at Tayport. Recorded by Robert Smith, June 1895.

S. conica L.
Very rare.
Recorded from (3) Elie by A. Craig Christie, Aug. 1882.

S. anglica L. (*English Catchfly*)
Sandy and gravelly fields. A doubtful native.
(2) St. Andrews (J. H. W.); (4) near Largo (J. R., 1843); (8) Inverkeithing (A. R., B.); N. Queensferry (D.); Dunfermline (N. S. A.); Ferry Hills (Dr. Graham, 1835).

var. **quinquevulnera** (L.)
(1) Shore of Lindores Loch (D.-H., 1878).

S. acaulis L. (*Cushion Pink*)
This is a plant of the mountains, so the N. S. A. record

from Balcarres Den (4) was probably an introduction. An old record from the Ochils is more likely to be correct. It is suggested that seed may have been sown there.

S. nutans L. (*Nottingham Catchfly*)
On limestone and chalky places. Very rare.
(8) N. Queensferry (Dr. Graham, 1826) and Inverkeithing, St. David's (A. C. C., 1880).
First record: Hooker, N. Queensferry Hills.

S. noctiflora L. (*Night-flowering Catchfly*)
Sandy and gravelly fields. Very rare.
(1) Lindores Loch (B. W. in Scot. Nat. 1879, p. 132); (2) St. Andrews (J. H. B.); (3) Fife Ness (W. Y.); Elie (W.) (F. M. W.) (J. H. B.); (4) Largo Links (J. K.); (8) N. Queensferry (D.); near Inverkeithing (A. R.) (B.); Dunfermline parish (N. S. A.).

Lychnis Linn.

L. alba Mill. (*White Campion*)
Fields. Common.
First record: North Queensferry (R. B. G., 1829).

L. dioica L. (*Red Campion*)
Fields, woods, and roadsides. Very common.
First record: (1) Balmerino parish (N. S. A).

L. Flos-cuculi L. (*Ragged Robin*)
Moist places. Common.
First record: N. Queensferry (R. B. G., 1837).

L. Viscaria L. (*Red German Catchfly*)
Dry rocks. Very rare.
(1) Newburgh (D. Don), (M.), (B.); (2) Dura Den (L. and S.); (4) Largo (J. K.); (7) Orrock Hill (W. Y.); Burntisland (R. B. G.).
First record: D. Don, east of Newburgh.

L. Githago Scop. (*Corn Cockle*)
Cornfields. Not common.
(1) Balmerino (J. C.); near Newport (W. E. E., 1910); (2) Tents Muir (J. H. B.); Falkland (A. C. C.); (3) between Anstruther and Elie (J. H. B.); (4) Kilconquhar (G. S.); Largo (J. H. B.); (7) Kirkcaldy (W. Y.); Burntisland

(B. and S.); (8) St. David's (A. C. C.); and N. Queensferry (R. B. G.).

First record: N. Queensferry (R. B. G., 1837).

L. coronaria Desr.

An alien.

Recorded from seashore at Inverkeithing by Trail, and specimen from Burntisland in Hb.R.B.G.

Cerastium Linn.

C. tetrandrum Curt.

Rocks and waste places on coast. Frequent.

(1), (3), (7), (8).

First record: Greville, Isle of May (3), D. Don.

[**C. pumilum** Curt.

Recorded by Trail, but very doubtful.]

C. semidecandrum L. (*Small Mouse-ear Chickweed*)

Dry places. Uncommon.

(2) Tents Muir (W. Y.); St. Andrews; (3) Isle of May; (4) Largo (J. H. B.); Balcarres; (7) Kirkcaldy (A. H. G.); Burntisland (W. L. L.); (8) N. Queensferry (J. H. B.) (F. M. W.); Ferry Hills (A. R.).

First record: Greville, Inchkeith (7) and Inchcolm (8).

C. viscosum L. (*C. glomeratum* Thuill.)

Fields and banks. Frequent.

(1), (2), (4), (6), (7), (8).

First record: Greville, N. Queensferry, 1836.

C. vulgatum L. (*C. triviale* Link)

Waste places. Common everywhere.

First record: J. H. Balfour, Inverkeithing, 1837.

C. arvense L.

Gravelly places. Frequent.

(1), (2), (4), (7), (8), (9).

C. cerastoides Britton (*C. trigynum* Vill.)

Very rare.

(2) Strathmiglo (J. Sadler, 1859, R.B.G.); (4) Balcarres, wall tops (W.); (7) Burntisland (J. H. B., 1858).

Stellaria Linn.

S. aquatica Scop.
Very rare.
(1) Balmerino (J. C.); (2) Pitlessie Mill, and Collessie and Cults parish (N. S. A.).

S. nemorum L. (*Wood Stitchwort*)
Woods and shady places. Rare.
(1) Birkhill Woods and Balmerino (R. S.); (2) Dura Den (J. H. W.); (3) East Neuk (W.); (4) Balcarres Den and Kilconquhar (N. S. A.); (8) Rosyth Woods (W. L. L., R.B.G.); (9) Cleish Woods (A. R., Trans. Bot. Soc. Edin.) and Cleish parish (N. S. A.).

S. media Vill. (*Common Chickweed*)
Common everywhere.
First record: Sibbald, Inchkeith (7).

S. apetala Ucria (*S. Boraeana* Jord.)
(3) Cambo Sands (G. S., May 1894). Only record.

S. neglecta Weihe var. **umbrosa** (Opiz)
(7) Pirniss Wood, Balmuto (Boswell Syme, May 1872, R.B.G.). Only record.

S. Holostea L. (*Greater Stitchwort*)
Woods and hedges. Common.
(1), (2), (3), (4), (7), (8).

S. palustris Retz.
(1) Lindores (G. S.); Balmerino (J. C.); (2) Tents Muir (W. Barclay); (3) East Neuk (W.); (8) Dunfermline (D., 1836, R.B.G.).

S. graminea L. (*Lesser Stitchwort*)
Dry heathy and bushy places. Common.
(1), (2), (3), (7), (8).
First record: Inverkeithing, 1836.

S. uliginosa Murr.
In wet places. Common.
(1), (2), (3), (4), (6), (7), (8).
First record: Ferry Hills, A. Robertson, 1836.

Arenaria Linn.

A. verna L. (*Vernal Sandwort*)
Very rare.
(2) Drumcarro Crag (B.); (8) N. Queensferry (Sonn.).

A. tenuifolia L.
Very rare.
(7) Near Pettycur (G. Don); (8) Fordel (A. R.).
First record: Hooker, Pettycur.

A. trinervia L.
Frequent.
(1), (2), (3), (4), (7), (8), (9).
First record: Cleish Castle, 1830 (R. B. G.).

A. serpyllifolia L.
Dry places and walls. Very common.
First record: Inverkeithing, 1836, Trans. Bot. Soc. Edin.

A. leptoclados Guss.
Dry places and walls.
(3) Elie (F. W. W.); (7) Burntisland (F. W. W.).
First record: Burntisland, F. W. Webb, 1876.

A. peploides L. (*Sea Purslane*)
Sandy sea-coasts. Frequent.
First record: Sibbald, " coast."

[**A. fasciculata** Don, Herb. Brit. No. 136 (*A. fastigiata* Sm.)
Don there says he " found it on some rocks in Fifeshire, but rare." The plant he saw was probably either *A. verna* L. or *A. tenuifolia* L.]

Sagina Linn.

S. maritima G. Don (*Sea Pearlwort*).
On sea-coast. Not common.
(2) Near St. Andrews (J. H. B.); (3) Crail (W. Y.); Isle of May (D. Don); (4) near Largo (C. G.); Innerleven (Jas. Hart, 1815, R.B.G.); (7) Dysart (J. Knapp); Burntisland (J. H. B.); (8) Inverkeithing (R. K. G.); Ferry Hills J. H. B.); near Charlestown (J. H. B.).
First record: Sibbald, " coast below Kinneil " (2).

S. apetala Ard.

Not common.

(1) Balmerino (J. C.); (2) Tents Muir (R. S.); (3) Isle of May (G. W.); (5) Innerleven (G. C. D.); Leslie (G. S.); (7) Kirkcaldy (W. Y.); (8) Inchcolm (A. C. C.); Inverkeithing (K. N. S.); N. Queensferry (Brodie, R.B.G.).

First record: A. Robertson, Inverkeithing, 1836.

S. ciliata Fr.

Dry places and sandy heaths. Rare.

(1) Near Newport (W. E. E., 1910); (2) West Lomond; (3) Chapel Ness, Elie (F. W. W.); (7) Orrock Hill (J. B. S.); (8) Inverkeithing (J. H. B.); N. Queensferry (A. C. C.).

First record: Inverkeithing, 1836.

S. procumbens L.

Waste ground. Common everywhere.

First record: Greville, N. Queensferry, 1839.

S. subulata Presl

Not common but widely distributed. Dry gravelly and sandy places.

(1), (2), (3), (8), (9).

First record: Hooker, hills near Newburgh.

S. nodosa Fenzl. (*Knotted Spurrey*)

Wet and sandy places. Scarce.

(1) Balmerino (J. C.); Forgan Bog (R. S.); (2) Tents Muir (W. G. S.); (3) Kilminning (G. S.); (4) Kilconquhar (B. and S.); Largo (J. H. B.); (7) by Camilla Loch (W. L. L.); Burntisland Reservoir (G. W.); (8) Inverkeithing (A. R.); (9) Bishop Hill (A. C. C.); by Loch Leven (G. W.); Benarty (W. Y., 1926).

Spergula Linn.

S. arvensis L. (*Spurrey*)

Very common in cultivated fields.

First record: W. Lauder Lindsay, Burntisland, 1848.

S. sativa Boenn.

Cultivated land. Very rare.

Only record: A. Craig Christie, Charlestown (8), Sept. 1873.

Spergularia Presl

S. rubra Pers. (*Purple Sandwort*).
Sandy fields and waste places. Very common.
First record: Sibbald, "coast."

S. salina Presl
These records, no doubt, mostly refer to *S. marginata* Kittel.
Seashore.
(1) Balmerino (J. C.); (2) St. Andrews (G. W.); (4) Largo (J. H. B.); Earlsferry (W.); (7) Wemyss (A. C. C.); (8) Dalgety Bay (R. S.); Aberdour and St. David's (J. H. B.); Inverkeithing (A. R.); N. Queensferry (B. and S.); near Torryburn (J. H. B.); Charlestown (B. and S.).
First record: Sibbald, "North Queensferry."

var. b. **media**
Recorded by Professor Trail. No locality.

var. c. **neglecta** (Syme)
(8) Inverkeithing (E. Young, 1834, R.B.G. and A. C. C., 1866).

S. marginata Kittel
(3) Crail (G. S.); (8) near St. David's (W. E. E., 1902); N. Queensferry (1837, R. B. G.); Inverkeithing (M.).

var. **glandulosa** Druce
(7) Near Burntisland (W. E. E., 1907).

Polycarpon Loefl.

P. tetraphyllum L.
Only record: A. Craig Christie, Charlestown (8), Sept. 1870.

PORTULACEAE.

Claytonia Linn.

C. sibirica L.
In woods. Very rare. Naturalised.
(5) Near Leslie (W. Y.); (8) Aberdour (Fraser); (9) Blairadam (A. C. C.).

Montia Linn.

M. fontana L. (*Blinks*)
Watery places. Frequent.
(1), (2), (3), (4), (7), (8), (9).

var. a. **minor** All.
(7) Balmuto (W. Y.); (8) Inverkeithing, 1836 (K. N. S.) (W. E. E., 1914); Shore between N. Queensferry and Burntisland, 1857.

var. b. **major** All.
(1) Lindores, Black, Don and Darg Lochs (G. W.).

HYPERICACEAE.

Hypericum Linn.

H. Androsaemum L. (*Tutsan*)
Waste places. Very rare. Introduced.
(8) Culross (A. R., 1834); "Fife" (1836, Maughan).
First record: Sibbald, "inland."

H. elatum Ait. (*H. anglicum* Bertol.)
(8) Culross (J. H. B., "introduced").

H. calycinum L. (*Rose of Sharon*)
Established in bushy places. Introduced.
(1) Balmerino, Naughton (J. C.); (4) Balcarres and Kilconquhar (B. and S.); (7) by Raith Lake (J. H. B.); Burntisland (1834, R. B. G.); (8) N. Queensferry (Greville).
First record: N. Queensferry, Greville.

H. perforatum L. (*St. John's Wort*)
Woods, hedge-banks, etc. Frequent.
(1), (2), (3), (5), (7), (8), (9).

H. maculatum Crantz (*H. dubium* Leers.)
Moist places by ditches, etc.
(1) Balmerino (J. C.); (2) Rankeilour (W. Y.); (3) Crail (G. S.); (7) Dunnikier (A. H. G.); Raith Woods.

H. quadrangulum L. (*H. tetrapterum* Fr.)
Wet places. Frequent.
(1), (2), (3), (4), (7), (8).
First record: Sibbald; without locality.

H. humifusum L.
Gravelly and heathy places. Frequent.
(1), (2), (3), (4), (7), (8), (9).

H. pulchrum L. (*Small upright St. John's Wort*)
Dry sandy heaths, banks, woods. Frequent.
(1), (2), (3), (7), (8), (9).
First record: Sibbald, no locality, as *H. elegantissimum.*

H. hirsutum L. (*Hairy St. John's Wort*)
Woods and thickets. Frequent.
(1), (2), (3), (4), (7), (8), (9).
First record: Greville, Burntisland, leg. Neill.

MALVACEAE.

Lavatera Linn.

L. arborea L. (*Tree Mallow*)
Doubtful native. Rocks by the sea. Very rare.
(3) Isle of May; Crail parish (in garden at Fife Ness) (N. S. A.); (4) near Elie (J. H. B.); Largo (W. Y., 1919); (7) near Kinghorn (J. H. B., 1863) (A. C. C., 1866) and (G. S.); (8) Inverkeithing (L. and S.); Inchgarvie (R. B. G.).
First record: Sibbald, Inchgarvie and Isle of May, as *Malva arborea marina.*

Malva Linn.

M. moschata L. (*Musk Mallow*)
Gravelly places. Doubtful native.
(1) Newburgh (J. H. B.); Lindores (A. L.); Balmerino (J. C.); (2) Rankeilour (W. Y., 1889); Cults Hills (M.); Cupar (J. H. B.); Crawford Priory and Collessie (N. S. A.); (4) Keil's Den, Largo (M.); Leven (M.); (7) Raith, Kirkcaldy (B. and S.); (8) Inverkeithing (B. and S.); Dunfermline parish (N. S. A.); Fordel (Dr. Dewar n. d.); (9) Cleish (B.).

M. sylvestris L. (*Common Mallow*)
Roadsides and waste places. Common.
(1), (2), (3), (4), (5), (7), (8).

M. rotundifolia L. (*Dwarf Mallow*)
Waste places. Rather common.
(1), (2), (3), (4), (7), (8).
First record: Sibbald, Inchcolm, as *M. pumila flore albo.*

TILIACEAE.

Tilia vulgaris Hayne (*Linden or Lime*)
Ornamental trees. All planted.

LINACEAE.

Radiola Hill

R. linoides Roth (*R. millegrana* Sm.) (*Allseed*)
Damp sandy places.
(1) Balmerino (J. C.); (2) Tents Muir (J. H. B., 1854) (W. E. E., 1907) (M.) and (R. S., 1894); Edensmuir (N. S. A.); (8) near Saline (A. R., Trans. Bot. Soc. Edin.); (9) near Loch Leven (J. H. B.); Orwell parish (N. S. A.); and near Kinross (A. R., Trans. Bot. Soc. Edin.).

Linum Linn.

L. catharticum L. (*Purging Flax*)
Dry pastures and banks. Common.
(1), (2), (7), (8).
First record: Greville, "between Pettycur and Burntisland."

L. usitatissimum L. (*Common Flax*)
Infrequent. Escaped from cultivation. Casual relic.
(3) Crail's Muir (G. S.); (6) Lochgelly (B. and S.); (7) Dysart (J. H. B.); Balmuto (J. B. S., 1874); Burntisland (F. M. W., R.B.G., 1848) and (W. E. E., 1902); (8) Crossgates (1865) and St. David's (1866–68, A. C. C.); Charlestown (W. L. L., 1847, R.B.G.).

GERANIACEAE.

Geranium Linn.

G. sanguineum L. (*Bloody Crane's-bill*)
Frequent.
(1), (2), (4), (7), (8), (9).
First record: Hooker; no locality.

G. phaeum L.
In woods and thickets. Rare. Naturalised.
(1) Balmerino (M.); (2) Rankeilour and Tarvit Wood,

Cupar (J. H. B., 1871) and (G. S., 1904); Rossie (M.); (7) Balmuto (W. Y., 1885); Raith (B. and S.); Burntisland (J. H. B.); (8) Aberdour (A. C. C.) and (B. and S.); Limekilns (J. H. B.).

First record: Hooker; no locality.

G. sylvaticum L.

Woods and thickets. Rare.

(1) Balmerino (J. C.); (2) Ladybank (J. H. B.); (3) Arncroach (W.); (7) Kirkcaldy (W. Y.); (8) banks of Black Devon (J. H. B.); Lethan's Glen; and (9) Blairadam (Trans. Bot. Soc. Edin.); Loch Leven (J. H. B.); Cleish parish (N. S. A.).

First record: Cleish parish (N. S. A.).

G. pratense L.

Moist pastures. Common throughout the county.

G. pyrenaicum Burm. fil.

Doubtful native. Roadsides and pastures. Rare.

(3) Earlsferry Point (W.); (7) Dunnikier (L. and S.); Burntisland (roadside near gravel quarry) (W. L. L., 1848, R.B.G.); (8) between Burntisland and Aberdour (J. H. B.); St. David's (J. H. B.); Inverkeithing (M.); N. Queensferry (B. and S.).

G. molle L.

Dry places. Very common.

G. pusillum L.

Uncommon.

(1) Lomond Hills (J. H. B.); (2) St. Andrews (D.-H.); near Leuchars (L. and S.); Falkland (B. and S.); (3) Earlsferry Point (W.); (7) Kirkcaldy (W. Y.).

[**G. rotundifolium** L.

Old walls and waste places. Doubtful.

(2) Kingskettle (L. and S.)].

G. dissectum L. (*Dove's Foot*)

Waste places. Not common.

(1) Balmerino (J. C.); Newburgh (A. L.); Newport (W. G. S.); (2) Cults parish (N. S. A.); near St. Andrews (J. H. W., 1858); (3) Crail (G. S.); (4) Balcarres Craig (C. G.); (7) Kirkcaldy (W. Y.); between Kinghorn and Burntisland

(J. H. B.); (8) Starleyburn (W. L. L.); Aberdour (A. C. C.); Donibristle (M.).

First record: New Statistical Account, Cults parish.

G. columbinum L.

On gravelly and limestone soils. Rare.

(1) Mare's Craig (J. H. B.); Balmerino (J. C.); Birkhill (L. and S.); (7) Dunnikier (L. and S.); (8) St. David's (B. and S.); Inverkeithing (J. H. B.); Ferry Hills (D., 1836, R.B.G.).

First record: Hooker, N. Queensferry, leg. Maughan.

G. lucidum L. (*Shining Crane's-bill*)

Rocks, walls, and hedge-banks. Rather local.

(1) Mare's Craig, Newburgh (J. H. B.); Scotscraig (R. S.); (2) Ladybank (J. H. B.); Monimail (N. S. A.); (4) Largo (W.); (7) Raith (Goodsir, 1840, R.B.G.); Burntisland (W. L. L., R.B.G.); (8) N. Queensferry (B. and S.); (9) Cleish parish (N. S. A.); Rumbling Bridge (J. H. B.).

First record: Greville, "A little north of Burntisland," leg. Arnott, behind Grange Distillery.

G. Robertianum L. (*Stinking Robert*)

Very common everywhere.

Erodium L'Hérit.

E. cicutarium L'Hérit. (*Stork's-bill*)

Dry pastures and sandy seashores. Common.

(1), (2), (3), (4), (7), (8).

var. **chaerophyllum** (Cav.)

(2) Near St. Andrews (D.-H., 1867).

First record: Lightfoot, as "*Geranium cicutarium*, a variety with white flowers, near Wemyss" (7).

E. moschatum L'Hérit.

Waste places. Very rare. Casual.

(3) Balcomie Links (G. S., Oct. 1885, certified C. C. Babington); (4) Kilconquhar (W.).

E. maritimum L'Hérit.

(3) Near Crail (G. S., 1885, in company of Professor Babington).

Oxalis Linn.

O. Acetosella L. (*Wood Sorrel*)
Woods and shady places. Common.
First record: Sibbald, Inchkeith (7), as "Sorrel."

AQUIFOLIACEAE.

Ilex Linn.

I. Aquifolium L. (*Holly*)
Woods and hedges. Doubtful native. Rare.
(1) Balmerino (J. C.); Scotscraig (W. G. S.); Birkhill Woods (R. S.); (3) East Neuk (W.); (8) Aberdour, Morton Woods (W. L. L.) and (B. and S.).

CELASTRACEAE.

Euonymus Linn.

E. europaeus L. (*Spindle-tree*)
Hedges and woods. Doubtful native.
(4) Kilconquhar (J. H. B., 1859); Balcarres Den (B. and S.); (7) Burntisland (J. H. B.); (8) Pitreavie (introduced, A. R., Trans. Bot. Soc. Edin.).

RHAMNACEAE.

Rhamnus Linn.

R. catharticus L. (*Buckthorn*)
Hedges and thickets. Very rare.
(8) Between Burntisland and Aberdour (J. H. B., 1868).

ACERACEAE.

Acer Linn.

A. Pseudo-platanus L. (*Sycamore*)
Woods. Doubtful native. Common.

A. campestre L. (*Maple*)
Woods. Introduced. Not common.
(7) Macduff Castle (J. H. B.); Dysart (B. and S.); (8) N. Queensferry (Brand) and (B. and S.); Inverkeithing (N. S. A.).

A. platanoides L.
Introduced.
(7) Plantation below the Binn, Burntisland (W. E. E., 1906).

LEGUMINOSAE.

Genista Linn.

G. anglica L. (*Needle Whin*)
Moist peaty heaths. Rather rare.
(1) Near Newburgh, Dovensdean (L. and S.); (2) Strathmiglo (J. H. B.); Falkland (C. G.); Collessie (N. S. A.); Ladybank (W. Y.); Edensmuir (N. S. A.); Tents Muir (B.); (3) between Anstruther and Elie (J. H. B.); (8) Torryburn (J. H. B.); (9) Blairingone (R. B. G.); Cleish Hills (Trans. Bot. Soc. Edin.); Orwell parish (N. S. A.).
First record: Hooker, (9) near Arlary, Kinross.

G. tinctoria L. (*Dyer's Weed*)
In pastures and thickets.
(4) Kilconquhar to west of manse (Wood).
A doubtful record; probably a garden escape.

Ulex Linn.

U. europaeus L. (*Furze, Whin, Gorse*)
Heaths and banks. Common everywhere.
(7) Dysart Woods (R. B. G., 1867), fl. pl. variety.

U. minor Roth (*U. nanus* Forster)
(1) Newport (W. G. S., 1886); also recorded by Professor Trail as occurring in the county, but without locality and as "very doubtful."

Cytisus Linn.

C. scoparius Link (*Broom*)
Dry hills and heaths. Very common everywhere.

Ononis Linn.

O. repens L. (*O. arvensis* L.) (*Restharrow*)
Dry sandy places, banks and railway banks. Common.

var. **horrida** Lange
(3) Rocks west of Elie (W. E. E., 1903).
White forms of the species have been found at (7) Pettycur and at (8) St. David's (A. R., 1834).

O. natrix L. (*O. ramosissima* Desf.)
Alien.
(8) St. David's (Rev. Mr. Little, R.B.G.); Inverkeithing (N. S. A., possibly on Rev. Mr. Little's authority); Starleyburn (A. C. C.).

[**O. spinosa** L.
Waste places.
Only record is by Professor Trail, without locality and described as "doubtful." No doubt *O. repens* L. var. *horrida* Lange.]

Trigonella Linn.

T. ornithopodioides DC. (*T. purpurascens* Lam.)
Dry gravelly places. Very rare.
(2) St. Andrews at Bridge over R. Eden; in Brodie's Herbarium, leg. J. Mackay, 1794; (7) Inchkeith (A. C. C., 1879); (8) Inverkeithing (K. N. S., 1836; A. Dewar, R.B.G., 1836; Wright, R.B.G., 1840).

Medicago Linn.

M. sativa L. (*Lucerne*)
Borders of fields. Not native.
(1) Newport (L. Carnegie, 1837, R.B.G.); (2) Cupar (J. H. B.); St. Andrews (D.-H., 1868); (3) Crail's Muir (G. S.); Saughur (W., now extinct); (4) Kilconquhar (J. H. B.); Lower Largo (R. B. G., 1845); Lundin Links (A. S., 1900); (7) Kirkcaldy (B. and S.); (8) Inverkeithing (B. and S.); Ferry Hills (Trans. Bot. Soc. Edin.).

M. lupulina L. (*Black Medick*)
Waste ground. Frequent.
(1), (2), (3), (4), (7), (8).

M. denticulata Willd.
Casual.
Recorded by Professor Trail, without locality.

M. arabica Huds. (*M. maculata* Sibth.)
On gravelly soil. Very rare.
(7) Near Kirkcaldy (B. and S.); (8) Dalgety (K. N. S., 1836); Donibristle (A. R., 1832); St. David's (A. C. C., 1870) (R. S., 1896) (W. E. E., 1906).

M. tornata Willd.
Alien.
(8) Ballast heaps, St. David's Bay (W. E. E., July 1902).

Melilotus Hill

M. altissima Thuill.
Casual.
(8) St. David's (W. E. E., 1902) (Fraser, 1904–1905).

M. alba Desr. (*M. leucantha* Koch)
Sandy and gravelly places near the sea. Very local.
(2) St. Andrews (D.-H., 1868); (8) St. David's (W. E. E., 1904); Inverkeithing and Charlestown (A. R., 1834) (W. L. L., 1848) (A. C. C., 1870); Limekilns (R. S.); near Torryburn (J. H. B., 1853).

M. officinalis Lam. (*M. arvensis* Wallr.) (*Common Melilot*)
Waste places.

Trifolium Linn.

T. pratense L. (*Purple Clover*)
Pastures and fields. Common.
(1), (2), (3), (7), (8), (9).

T. medium L.
Dry pastures. Frequent.
(1), (2), (3), (4), (8).

T. arvense L. (*Hare's-foot Trefoil*)
Sandy fields and dry banks. Frequent.
(1), (2), (4), (7), (8).
First record: Sibbald, (8) "between Dalgety and Aberdour."

T. striatum L. (*Soft Knotted Trefoil*)
Dry and sandy places. Frequent.
(1), (2), (3), (4), (7), (8).
First record: Greville, "Banks facing the sea at North Queensferry (8). Plentiful."

T. scabrum L.
Dry sandy places. Rare.
(3) Between Elie and Anstruther (J. H. B.); (4) road between Largo and Colinsburgh (W.); (7) shore at Dysart (F. M. W.); Orrock Hill (F. M. W.); Kinghorn (G. S.);

Burntisland (K. N. S., 1836, and A. R.); Pettycur (B. and S.); (8) Inverkeithing (A. R.).

First record: 1826, R. B. G., Edin.; specimen, no collector.

T. strictum L.

Introduced.

(1) Fincraigs, Balmerino (J. C.). Only record.

T. hybridum L. (*Alsike Clover*)

Fields. Introduced. Casual.

(1) Newport (W. G. S., 1885); (7) Kirkcaldy (W. Y.); Kinghorn (J. H. B.); (8) N. Queensferry (A. C. C., 1866); Charlestown (J. H. B.).

T. repens L. (*Dutch or White Clover*)

Meadows, pastures, and roadsides. Common.

A viviparous variety collected by Dr. Dewar at N. Queensferry (Sept. 1836) is in the Herbarium of the R.B.G.

T. fragiferum L.

Damp pastures.

(2) At Bridge over Eden at St. Andrews (Oct. 1794), in Brodie's Herbarium at R.B.G., leg. J. Mackay. Only record.

T. procumbens L.

Dry pastures. Frequent.

(1), (2), (3), (4), (7), (8).

T. dubium Sibth. (*T. minus* Sm.)

Dry places. Frequent.

(1), (2), (3), (4), (7), (8).

T. filiforme L.

No doubt mostly *T. dubium* Sibth.

Dry places. Very rare.

(2) Law Park, St. Andrews (J. H. W.); (3) East Neuk of Fife (W., common); (4) near Kilconquhar (C. G.); (7) Burntisland (B. and S.); Donibristle (K. N. S., 1836); St. David's (J. H. B.); N. Queensferry (B. and S.); Kincardine (J. H. B.).

T. spumosum L.

Alien. Ballast plant.

Recorded from Burntisland Docks by F. M. Webb, Sept. 1877.

Anthyllis Linn.

A. Vulneraria L. (*Lady's Fingers*)

Dry pastures. Common.

(1), (2), (3), (7), (8).

First record: J. Mackay, N. Queensferry, 1794 (R.B.G.).

Lotus Linn.

L. corniculatus L. (*Bird's-foot Trefoil*)

Pastures, dry banks, etc. Common in all districts.

First record: Aberdour, Professor J. H. Balfour, June 1839 (R.B.G.).

L. tenuis Waldst. et Kit.

Meadows and moist banks. Very rare.

(4) Roadside near Balcarres (C. G.); (8) Donibristle (A. R., Trans. Bot. Soc. Edin.).

L. uliginosus Schkuhr (*L. major* Scop.)

In damp places. Frequent.

(1), (2), (3), (4), (7), (8), (9).

First record: Donibristle, 1836.

Astragalus Linn.

A. danicus Retz. (*A. hypoglottis* L.)

Chalky and gravelly places. Not common.

(1) St. Fort (W. G. S.); (2) Tents Muir (F. W. W.); St. Andrews (G. W.); (3) Crail (G. S.); Pitmilly Links, albino; near Elie (J. H. B.); Kilrenny (N. S. A.); (4) Largo (J. H. B.); (7) shore to west of Kirkcaldy (W. Y.); Kilrie (J. B. S.); Burntisland (J. H. B.); (8) N. Queensferry (W. A., 1829); Ferry Hills (R. B. G.); near Dunfermline, albino (J. H. B.).

First record: Ferry Hills, J. Mackay, 1794 (R.B.G.).

A. glycyphyllos L. (*Wild Liquorice*)

Gravelly banks near the sea. Rare.

(1) Wormit (R. S.); (3) between Kincraig and Elie (W. Y., 1920); (7) Seafield Tower (A. H. G.); Pettycur (J. B. S.); Burntisland (A. C. C.) (T. Wilson, 1935, abundant); (8) Inverkeithing and Ferry Hills (A. R.).

First record: Sibbald, Inchkeith (7).

Oxytropis DC.

O. uralensis DC. (*Mountain Milk-vetch*)

Hilly pastures. Extremely rare.

(8) Hills about N. Queensferry. (At one time plentiful but

has not been seen for many years. Situation was destroyed when railway cutting for approach to Forth Bridge was made. There are many specimens in the R.B.G., from 1794 (Mackay) to 1860.) Inverkeithing (N. S. A.); (9) Bishop Hill (J. H. B.). At one time abundant but has not been seen for many years.

Ornithopus Linn.

O. perpusillus L. (*Bird's Foot*)

Dry sandy and gravelly places. Uncommon.

(1) Mare's Craig (J. H. B.); Clachard (A. L.); near Newport (W. E. E.); (2) Cults (B.); Falkland (C. G.); (8) Ferry Hills (A. R.); N. Queensferry (Knapp, R.B.G.); (9) Kinross-shire (Dr. M'Nab, R.B.G.); Orwell parish (N. S. A.).

First record: Greville, N. Queensferry, leg. Dr. Graham.

Onobrychis Hill

O. viciaefolia Scop. (*Sainfoin*)

Introduced. Recorded by Wood in (3) East Neuk without locality.

Vicia Linn.

V. hirsuta Gray (*Hairy Tare*)

Cornfields and hedges. Very common everywhere.

V. tetrasperma Moench (*V. gemella* Crantz)

Fields and hedges. Very rare. Introduced.

(3) East Neuk (W.); (7) Burntisland (B. and S.) and (W. E. E., 1907); (8) St. David's (Gilbert M'Nab, 1835, R.B.G.); and Charlestown (J. H. B.).

V. Cracca L. (*Tufted Vetch*)

Hedges. Frequent.

(1), (2), (3), (4), (7), (8), (9).

V. Orobus DC. (*Bitter Vetch*)

Woods. Rare.

(1) Newburgh (Hooker); Balmerino (J. C.); Drumcarro Craig (H.); (3) East Neuk (W.).

V. sylvatica L. (*Wood Vetch*)

Woods and thickets. Rare.

(1) Tayport (M.); Ferryport (B.); (7) Burntisland (J. H. B.); (8) Dunfermline parish (N. S. A.); (9) Rumbling Bridge (J. H. B.).

V. sepium L.
Woods and hedges. Frequent.
(1), (3), (7), (8), (9).

V. lutea L. (*Yellow Vetch*)
Stony sea-coasts. Very rare. Native.
(1) Norman's Law (L. and S.); (8) N. Queensferry and Ferry Hills. Recorded by various collectors at various dates down to 1904. Specimens are in R.B.G.Ed.
First record: Greville, "Seaside west of N. Queensferry, G. Don." "It is still there" (Dr. Graham in 1820).

V. sativa L. (*Common Vetch*)
Escape from cultivation. Frequent.
(1), (3), (4), (7), (8), (9).
First record: A. Robertson, St. David's, 1835.

V. angustifolia L.
Dry places. Rather local.
(2) St. Andrews (D.-H., 1867); (3) Craighead Quarry, Fife Ness (G. S.); (7) Balmuto (W. Y.); (8) St. David's (J. T. S., R.B.G.); Ferry Hills (K. N. S., 1836); N. Queensferry (J. H. B.).

var. **Bobartii** Koch
(8) St. David's (A. R., 1835); Ferry Hills (K. N. S., 1836) (A. Dewar, 1836, R.B.G.).

V. lathyroides L. (*Spring Vetch*)
Dry pastures. Frequent. Native.
(1) Norman's Law (L. and S.); and near Newport (W. G. S.); Balmerino (J. C.); (2) St. Andrews (J. H. W.); (3) Crail (G. S.); (7) Burntisland (B. and S.); (8) N. Queensferry (Brand, 1833, R.B.G.); Rosyth (1835, R. B. G.).
First record: Greville, Burntisland, leg. Arnott.

V. bithynica L.
Casual.
(7) Kinghorn (W. E. E., 1903) (Trail, A. S. N. H., 1905).

V. Ervilia Willd.
Alien.
(7) Burntisland (Fraser, 1906, A. S. N. H.).

Lathyrus Linn.

L. Aphaca L. (*Yellow Vetchling*)

Sandy and gravelly fields. Ballast plant.

(7) Burntisland Docks (F. W. W., 1878, R.B.G.); (8) Charlestown (A. C. C., 1873).

[**L. hirsutus** L.

Recorded from (4) Kilconquhar by Wood; but doubtful.]

L. pratensis L.

Moist meadows. Rare.

(1) Lindores Loch (A. L.); Balmerino (J. C.); Newport and St. Fort (W. G. S.); (2) Falkland (B. and S.) and Kinness Burn (J. H. W.); (4) Kilconquhar (W.) and (B. and S.); (7) Balwearie, near Kirkcaldy (A. H. G., R.B.G.); Dysart (B. and S.); (8) N. Queensferry (B. and S.); Kincardine (J. H. B.); (9) Orwell parish (N. S. A.).

L. latifolius L.

Doubtful. Probably *L. sylvestris* L.

(1) Balmerino (J. C.).

L. tuberosus L.

Introduced. Very rare in Britain.

(7) Near Kinghorn (J. L. Dawson, 1935).

L. sylvestris L.

Woods and thickets. Rare.

(1) Balmerino and Ladeddie (R. S.); (2) Dairsie (R. S.); (9) Cauldron Linn (B. and S.).

L. montanus Bernh. (*L. macrorrhizus* Wimm.)

Woods and borders of fields. Frequent.

(1) Newburgh (A. L.); Balmerino (J. C.); Wormit (R. S.); Tayport (W. G. S.); (2) Falkland (B. and S.); Cults parish (N. S. A.); Tents Muir (A. H. G., R.B.G.); Kinkell Braes (J. H. W.); (3) Fife Ness (G. S.); (7) Pettycur (B. and S.); (8) N. Queensferry (B. and S.); Donibristle (A. R.); (9) Cleish Hills (R. S.); Loch Leven (J. H. B.).

First record: Sibbald, coast as *Orobus tuberosus*.

var. **tenuifolius** Roth

(2) Kinkell (G. S.); (3) Crail (G. S.); (7) Kirkcaldy.

L. grandiflorus Sibth. et Sm.

Alien. Garden escape.

(8) Near Otterston Loch (W. E. E., 1903).

ROSACEAE.

Prunus Linn.

P. spinosa L. (*P. communis* Huds.) (*Sloe* or *Blackthorn*)
Woods and hedges. Common.
(1), (2), (3), (4), (7), (8), (9).

P. insititia L. (*Bullace*)
Woods and thickets. Rare. Introduced.
(2) Near Ladybank (J.H.B., 1859); (7) Burntisland (B. & S.); (8) near Aberdour (J.H.B.); Fordel Woods (A.R., Trans. Bot. Soc. Edin.); Inverkeithing (A.R.).

P. domestica L. (*Plum*)
Woods. Introduced. Very rare.
(7) Macduff Castle (C.G.); (8) Ferry Hills (A.R., Trans. Bot. Soc. Edin.); near Aberdour (J.H.B.); Inverkeithing (A.R.); Kincardine (Sonn.); (9) Rumbling Bridge (J.H.B.).

P. Avium L. (*Wild Cherry, Gean*)
Woods. Frequent.
(1) Balmerino (B.); Birkhill Woods (R.S.); Newport (W.G.S.); (3) Airdrie Woods (G.S.); (7) Raith (A.H.G., R.B.G.).

P. Cerasus L. (*Dwarf Cherry*)
Hedges. Rare.
(1) Ballinbreich Castle (A.L.); Balmerino (R.S.); (3) East Neuk (W.); (7) Dunnikier (A.H.G., R.B.G.).

P. Padus L. (*Bird Cherry*)
Woods and hedges. Occasional.
(3) Cambo (G.S., introduced); (4) Keil's Den, Largo (M.); (7) Raith (A.H.G., R.B.G.); (8) Lethan's Glen and Culross; (9) Cleish parish (N.S.A., & M.); Kinross-shire (Dr. Stuart, 1836, R.B.G.).

Spiraea Linn.

S. salicifolia L. (*Willow-leaved Spiraea*)
Woods. Very rare. Introduced.
(1) Balmerino (J.C.); St. Fort (W.G.S.); (2) Ladybank (W.Y.); (6) Cameron Bridge (W.Y.); (8) N. Queensferry (B. & S.); Pitreavie (R.S.); (9) Rumbling Bridge (J.H.B.); Cleish Woods (Hooker).

S. Ulmaria L. (*Meadow-sweet*)
Damp meadows, ditches, etc. Very common everywhere.

S. Filipendula L. (*Dropwort*)
Dry pastures. Rare.
(1) Balmerino (Knapp, 1837); (2) Collessie parish (N.S.A.); Eden Muir (B.); St. Andrews (J.H.W.); (4) Largo (Knapp); (7) Burntisland (B. & S.); (8) St. David's (W.Y.); Inverkeithing (Knapp, 1836); N. Queensferry (W.L.L.).
First record: Sibbald, Burntisland Castle.

Rubus Linn.

R. idaeus L. (*Bramble*)
Woods and waste places. Common everywhere.

var. **obtusifolius** Willd. (*R. Leesii* Bab.)
Very rare.
(2) St. Andrews (Dr. M'Tier, 1882, R.B.G.).

R. suberectus Anders. (*Upright Bramble*)
Very rare.
(2) Near St. Andrews (J.H.B., 1858); (7) Kirkcaldy (Sonn.).

R. plicatus Wh. & N. (*R. fruticosus* Arrh.)
Rare.
(1) Balmerino (J.C.); Wormit (R.S.); Scotscraig (W.G.S.); (3) East Neuk (Wood); Balcarres Den (C.G.); (8) Pitreavie (R.S.); N. Queensferry (Sonn.).

R. nitidus Wh. & N.
(1) Scotscraig (R.S., 1900); (2) near Dairsie (R.S., 1897).

R. affinis Wh. & N.
(7) Dunnikier (A.H.G., 1882, R.B.G. "or *suberectus* ?"); (8) N. Queensferry (Sonn.).

R. carpinifolius Wh. & N. (*Hornbeam-leaved Bramble*)
(3) Elie (Sonn.); (7) Balmuto (J.B.S., 1872, R.B.G.).

R. rhamnifolius Wh. & N.
(7) Balmuto (J.B.S., 1873, at Kew Herbarium as "*R. plicatus*"); also recorded by Trail in A.S.N.H.

var. **Bakeri** F. A. Lees
Recorded by Trail in A.S.N.H. without locality.

R. nemoralis P. J. Muell. var. **glabratus** Bab.
(7) Balmuto (J.B.S., 1874, R.B.G.).

R. Lindebergii P. J. Muell.
Recorded by Trail in A.S.N.H. without locality.

R. macrophyllus Wh. & N.
(7) Balmuto (J.B.S., 1873, R.B.G. "between *R. amplificatus* and *glabratus*," C. C. Babington).

R. mucronatus Blox.
(7) Balmuto (J.B.S., 1872, "cucullate form," R.B.G.) (F.W.W., 1876, "*mucronulatus*," R.B.G.); Kirkcaldy, Linktown Road, Old Lane (F.W.W., 1876).

R. radula Weihe
(7) Balmuto, Orrock Hill, and Grange Quarry (J.B.S., 1872, R.B.G.); Dysart (A.H.G., 1882, R.B.G.); Burntisland, near Grange Distillery (F.W.W., 1876, R.B.G.).

R. rudis Wh. & N.
(2) Near Law Park, St. Andrews (J.H.W., 1858).

R. oigoclados Muell. et Lefv. var. **Newbouldii** Rogers
Recorded by Trail in A.S.N.H. without locality.

R. corylifolius Sm.
(3) East Neuk (W.); (7) Balmuto (J.B.S., 1872, R.B.G.); Burntisland (B. & S.); (8) Aberdour (A.C.C., 1865): Ferry Hills (J.H.B., 1856).

R. caesius L.
(1) Balmerino and Birkhill Woods (R.S., 1898); (3) East Neuk (W.); (8) near Kincardine (J.H.B.).

Note. For many years little attention has been given by any botanist to the Brambles: doubtless other species exist in the county.

R. saxatilis L. (*Stone Bramble*)
(1) Balmerino (J.C.); (8) Dunfermline parish (N.S.A.); Lethan's Dene (A.R.); Saline Hills; (9) Black Devon (J.H.B.); Orwell parish (Trail, A.S.N.H.); Rumbling Bridge (J.H.B.).

Geum Linn.

G. urbanum L. (*Wood Avens*)
By sides of roads, hedges, woods, etc. Very common.
First record: New Statistical Account. Balmerino parish.

G. rivale L. (*Water Avens*)
Damp woods, ditches, etc. Frequent.
First record: Leighton & Swan; Area (1).

G. intermedium Ehrh.

Not common. A hybrid between the preceding species.

(1) Birkhill Woods (R.S.); (2) Kinness Burn (J.H.W.); (3) Crail (G.S.); (4) near Upper Largo (W., and W.Y.); (5) Markinch (A.C.C.); (7) Raith (J.H.B., 1870, and A.H.G., 1883, R.B.G.); The Loan, Kirkcaldy (W.Y.); (8) Pitreavie (R.S.).

Fragaria Linn.

F. vesca L. (*Wood Strawberry*)

Sunny hills, woods, pastures, etc. Common.

F. moschata Duchesne (*F. elatior* Ehrh.)

Near houses. An escape. Rare.

(4) Near Largo (W.); (7) near Kinghorn (J.H.B., R.B.G.); (8) Aberdour (A.H.G., R.B.G.); near Fordel (A.R., Trans. Bot. Soc.; K.N.S., 1837).

Potentilla Linn.

P. norvegica L.

(8) St. David's (A.C.C., August 1866). Only record.

P. sterilis Garcke (*P. Fragariastrum* Ehrh.) (*Barren Strawberry*)

Waste places. Frequent.

(1), (3), (4), (7), (8).

P. verna L. (*Spring Cinquefoil*)

Dry pastures. Not common.

(1) Scotscraig (R.S.) and near Newburgh (Hooker); (7) Kirkcaldy and near Kinghorn (J.B.S.); (8) N. Queensferry (A.C.C.); Ferry Hills (Knapp, 1835); Inverkeithing (J.H.B.).

First record: Greville, "hills about N. Queensferry, Maughan."

P. erecta Hampe (*P. sylvestris* Neck., *P. Tormentilla* Neck.) (*Tormentil*)

Dry heathy pastures. Common.

First record: Sibbald as "*Tormentilla officinarum.*"

P. procumbens Sibth.

Very rare.

(3) Crail's Muir (G.S., 1888); (8) Inverkeithing (J.H.B.).

P. reptans L. (*Cinquefoil*)
Roadsides and banks. Frequent.
(1), (2), (3), (4), (7), (8).
First record: Hooker, " near Kirkcaldy," leg. Stewart.

P. recta L.
Casual.
(4) Lathones (R.B.G.).

P. inclinata Vill.
Alien.
(7) Rocks near Burntisland Docks (W.E.E., 1903).

P. anserina L. (*Silverweed*)
By roadsides. Everywhere.

P. argentea L. (*Hoary Cinquefoil*)
Rare.
(1) Mare's Craig (A.L.); near Wormit (R.S.); near St. Fort (W.G.S.); (7) Balwearie Braes (A. Templeman); (8) near Torryburn (J.H.B.).

P. fruticosa L. (*Shrubby Cinquefoil*)
Woods and bushy places. Very rare. Introduced.
(7) Raith (A.C.C., 1867, and A.H.G., 1882).

P. palustris Scop. (*Comarum palustre* L.) (*Marsh Cinquefoil*)
Marshes and boggy places. Common.
First record: Greville, " N. Queensferry, 1820, R.B.G."

Alchemilla Linn.

A. arvensis Scop. (*Field Lady's Mantle*)
Dry sandy fields. Very common.

A. vulgaris L. (*Common Lady's Mantle*)
Pastures, roadsides, etc. Very common.

var. **filicaulis** (Buser)
Recorded by Trail (A.S.N.H.) without locality.

A. alpina L. (*Alpine Lady's Mantle*)
(2) St. Andrews Links (C.G.); doubtful, but specimen is said to be in Dr. J. H. Wilson's Herbarium.

Agrimonia Linn.

A. Eupatoria L. (*Common Agrimony*)
Borders of fields and waste places. Frequent.
(1), (2), (7), (8).

A. odorata Mill. (*Scented Agrimony*)
Waste places. Very rare.
(3) Crail's Muir Quarry (G.S.); (4) Dunbarnie Links, Largo.

Poterium Linn.

P. Sanguisorba L. (*Salad Burnet*)
Dry pastures. Rare.
(2) Collessie parish (N.S.A.); Stratheden; (4) near Largo (W.Y.); (7) between Wemyss and Burntisland (J.H.B.); (8) St. David's (W.Y.); Aberdour (B. & S.); Dunfermline (L. & S.); near Saline (Maughan).

P. polygamum W. et K. (*P. muricatum* Spach)
Waste places. Very rare.
(4) Largo (W.Y., 1919); Top. Bot. (A. Bennet, 1905); A.S.N.H. (1896, p. 197).

Rosa Linn.

R. spinosissima L. (*R. pimpinellifolia* L.)
Waste and sandy places by seashore. Frequent
First record: Hooker, Benarty Hill (9).

var. **typica** Wolley-Dod
(7) Burntisland (R.B.G., 1835), seashore near Dysart (R.B.G. 1854); (9) near Tillyrie, Milnathort (J.R.M.).

R. mollis Sm. (*R. villosa* L.)
Waste places. Frequent.
First record: Lightfoot, "coast of Fife" as "*R. villosa*"

R. pomifera Herrm.
Very rare.
(8) Near St. David's (W.E.E. & J.R.M.).

R. omissa Déségl.
Common.

var. **resinosoides** Crépin
(1) Newburgh (W. Barclay); (7) Burntisland; (8) Inverkeithing; (9) Milnathort and Crook of Devon (all J.R.M.)

var. **submollis** (Ley)
(9) Near Milnathort (J.R.M.).

var. **typica** Kell.
Recorded by J.R.M.
(7) Burntisland; (8) Inverkeithing; (9) Milnathort and Crook of Devon.

var. **Sherardi** Davies
(9) Near Milnathort (J.R.M.).

var. **uncinata** Lees
(8) Inverkeithing (J.R.M.).

var. **suberecta** Ley
(7) Burntisland ; and (9) Milnathort (J.R.M.).

var. **cinerascens** Dum.
(9) Near Blairadam (J.R.M.).

R. scabriuscula Sm.
(2) Cults parish (N.S.A. and L. & S.) ; (7) Burntisland.

R. tomentosa Sm.
Common.
First record : Lightfoot, " on coast " as *R. villosa.*

var. **eglandulosa** Wolley-Dod
(9) Near Milnathort (J.R.M.).

var. **pseudo-cuspidata** Crépin
(7) Near Burntisland (J.R.M.).

var. **scabriuscula** Baker
(9) Near Milnathort (J.R.M.).

R. cuspidatoides Crépin var. **foetida** (Bast.)
Recorded by Trail in A.S.N.H. without locality.

R. Eglanteria Huds. (*R. rubiginosa* L.)
Frequent.

var. **apicorum** Rip.
(1) Near Newburgh (W. Barclay, 1918).

var. **echinocarpa** Gren.
(8) Near Inverkeithing (J.R.M.).

R. canina L. (*Common Dog-rose*)
Waste places. Common in all districts.

var. **lutetiana** Léman
(7) Between Kirkcaldy and Auchtertool (A.H.G., 1882, R.B.G.), and Kinghorn and Burntisland; (8) Inverkeithing; (9) near Blairadam (all J.R.M.).

var. **mucronulata** (Déségl.)
(7) Burntisland (J.R.M.).

var. **insignis** (Déségl. et Rip.)
(2) Gateside ; and (9) Blairadam (J.R.M.).

var. **verticillacantha** Baker
(9) Near Blairadam (J.R.M. " very rare ").

var. **sphaerica** (Gren.)
(7) Between Kinghorn and Burntisland ; (8) Inverkeithing ; and (9) Blairadam (all J.R.M.).

var. **dumalis** (Bechst.)
(7) Between Kinghorn and Burntisland (J.R.M.).

var. **adscita** (Déségl.)
(7) Burntisland (J.R.M.).

var. **senticosa** Baker
(7) Between Kinghorn and Burntisland (J.R.M.).

R. dumetorum Thuill.
(7) Burntisland (F.M.W., July 1876, R.B.G.).

var. **semiglabra** (Rip.)
(7) Burntisland ; (8) Inverkeithing ; (9) Milnathort and Mawcarse (all J.R.M.).

var. **jactata** (Déségl.)
(8) Near Inverkeithing (J.R.M.).

var. **ramealis** (Pug.)
(9) Blairadam (J.R.M.).

R. glauca Vill.
(7) Orrock Hill (J.B.S., 1876).

var. **Reuteri** (Godet)
(2) Near St. Andrews (C. Bailey) ; (7) Between Kinghorn and Burntisland ; and (9) near Milnathort (J.R.M.).

var. **transiens** (Gren.)
(9) Blairadam and Milnathort (J.R.M.).

var. **subcristata** (Baker)
(7) Near Burntisland and Kinghorn (F.W.W.) ; (9) Kinross-shire (J.R.M.).

var. **myriodonta** (Chr.)
(7) Near Burntisland (F.M.W., R.B.G.) ; (9) near Milnathort (J.R.M.).

var. **adenophora** (Gren.)
(1) Near Newburgh (W.B., 1918) ; (9) Blairadam, Milnathort, and Crook of Devon (J.R.M.).

var. **stephanocarpa** (Déségl. et Rip.)
(9) Same as last (J.R.M.).

R. coriifolia Fries

var. **typica** Chr.
(9) Near Milnathort and Crook of Devon (J.R.M.).

var. **frutetorum** Chr.
(9) Milnathort (J.R.M.).

var. **Watsoni** (Baker)
(7) Near Balmuto (F.M.W., 1876, R.B.G.); (9) near Milnathort in several places (J.R.M.).

var. **subhispida** Wolley-Dod
(9) Kinross-shire (J.R.M., frequent).

var. **Bakeri** (Déségl.)
(9) Near Milnathort and at Mawcarse (J.R.M.).

var. **setigera** Wolley-Dod
(9) Near Milnathort (J.R.M.).

var. **Lintoni** Scheutz
(1) Near Newburgh (W.B., 1918); (9) near Milnathort (J.R.M.).

var. **subcoriifolia** (Barclay)
(9) Near Crook of Devon (J.R.M., frequent).

var. **incana** (Borr.)
(9) Crook of Devon and Milnathort (J.R.M.).

var. **subcollina** Chr.
(9) Milnathort (J.R.M.).

var. **caesia** (Sm.)
(9) Milnathort (J.R.M.).

var. **obovata** (Baker)
(9) Milnathort (J.R.M., rare).

R. arvensis Huds.
(2) Cults parish (N.S.A.); Cults and Ceres (M., and B.); (3) Elie; (8) Fordel (K.N.S., 1837).

var. **ovata** (Desr.)
(8) Near Aberdour (F.M.W., 1876).

R. sempervirens L.
Introduced.
(7) Near Burntisland (W.L.L., 1848, R.B.G.).

Pyrus Linn.

P. Aria Ehrh. (*White Beam-tree*)

Woods. Rare. Doubtful native.

(2) St. Andrews (B.); (3) Kinaldy (G.S.); (6) Kinglassie Woods (B.); (7) near Dysart (J.H.B.); Invertiel Quarry (A.H.G.); (8) Limekilns (B. & S.).

P. intermedia Ehrh.

Introduced.

Recorded by Trail in A.S.N.H. without locality.

(7) Wood below the Binn, Burntisland (W.E.E., 1903).

P. scandica Aschers.

(9) Crook of Devon (J.B.S., 1870, "planted," R.B.G.).

P. semipinnata Roth (*P. pinnatifida* Ehrh.)

(8) Pitreavie (W.L.L., June 1849, R.B.G.).

P. Aucuparia Ehrh. (*Rowan, Mountain Ash*)

Woods. Doubtful native.

(1) Balmerino (J.C.); (2) Falkland; (3) Kenly Den (G.S.); (7) Dunnikier (A.H.G., R.B.G.); (8) Inchcolm (Neill); Pitreavie (W.L.L.); (9) Cleish Hills (R.S.).

First record: Greville, Inchcolm, leg. Neill.

P. Malus Linn. (*Crab Apple*)

(2) Near St. Andrews (J.H.W.); (7) Dysart Woods (J.H.B., 1850); Burntisland (J.H.B., 1851); near Torryburn (Trans. Bot. Soc. Edin.).

Crataegus Linn.

C. monogyna Jacq. (*Hawthorn, May*)

Hedges and woods. Common everywhere.

SAXIFRAGACEAE.

Saxifraga Linn.

S. stellaris L. (*Starry Saxifrage*)

Very rare.

(2) West Lomond Hill (B. & S.); (9) Ochil Hills (1847, R.B.G.).

S. Geum L.

Introduced.

(2) Claremont Den (J.H.W., 1851); (7) Dysart Woods (J.H.B., June 1848).

S. umbrosa L. (*London Pride, None-so-pretty*)
Introduced.
(2) Falkland (B. & S.); near Cupar and near St. Andrews (J.H.B.); (3) Cambo Den (G.S., 1865, introduced); (7) Dysart (W.Y.); Auchtertool Linn (N.S.A.); (8) N. Queensferry (B. & S.); Inverkeithing (J.H.B.); (9) Lomond Hills and Rumbling Bridge (J.H.B.).

S. aizoides L. (*Yellow Mountain Saxifrage*)
(9) Lomond Hills (M., and B.).

S. tridactylites L. (*Rue-leaved Saxifrage*)
Moist rocks and tops of walls. Rare.
(2) North of St. Andrews Links (G.S., 1867, with J.H.B.); (3) Elie (Fraser, & A.C.C.); near Colinsburgh (W.); Kilconquhar (W.E.E., 1909); (7) near Kirkcaldy (Maughan, long extinct): Kinghorn parish (N.S.A.); Burntisland Binn (R.B.G.); (8) Carnock parish (N.S.A.); near Knock Hill (J.H.B.).
First record: Sibbald; no locality.

S. granulata L. (*White Meadow Saxifrage*)
Dry banks, pastures. Frequent.
First record: Greville, N. Queensferry.

S. hypnoides L. (*Mossy Saxifrage*)
Wet places on hills. Very local.
(2) West Lomond Hill (A.H.G., 1882); (9) Lomond Hills (A.R., Trans. Bot. Soc. Edin.) (J.H.B., 1855) (W.Y.): Queich Glen (1839, R.B.G.); Rumbling Bridge (J.H.B.).

Chrysosplenium Linn.

C. oppositifolium L. (*Common Golden Saxifrage*)
Shady damp places. Common.

C. alternifolium L. (*Alternate-leaved Golden Saxifrage*)
Shady places near springs. Rare.
(2) Maspie Den (R.S.); (8) Inverkeithing (N.S.A.); Fordel (A.R., 1837); Saline Hill (J.H.B.); (9) Cleish parish (N.S.A.); Lomond Hills (J.H.B.).

Parnassia Linn.

P. palustris L. (*Grass of Parnassus*)
Bogs, marshes, glens. Rare.
(1) Newburgh Hills (A.L.); Logie parish (N.S.A.); near Butterwell (A.L.); (2) Drumcarro Crag, Tents Muir (B.);

(4) Largo (Knapp, R.B.G.); (7) near Burntisland (A.C.C.); (8) Inverkeithing (K.N.S.); Dunfermline (B. & S.); Saline Hills; Lethen's Glen (A.R., 1835); (9) Cleish parish (N.S.A.); Loch Leven (J.H.B.); Lomond Hills (B. & S.).

First record: Sibbald; no locality.

var. **condensata** Travis et Wheldon

Recorded by J. B. Syme from Dunbarnie Links, near Largo, Sept. 1877, and seen there by the author in Sept. 1919 and 1920, growing and flowering in wet sandy hollows. Instead of a single flower spike there were several, closely crowded together and not so tall as usual form. See Journal of Botany for article by J. A. Wheldon on same form found in Lancashire (1912, p. 254, and 1913, p. 85).

Ribes Linn.

R. Grossularia L. (*Common Gooseberry*)

Woods and hedges. Doubtful native.

(1) Balmerino (R.S.); (2) Shaw Park, St. Andrews (J.H.W.); (3) Kenly Den (G.S.); (4) Leven Links (C.G.); (7) Dunnikier (A.H.G.); (7) Dysart Woods (J.H.B.); (8) Starleyburn (W.L.L.); Aberdour (B. & S.).

R. alpinum L. (*Mountain Currant*)

Introduced.

(3) Cambo (G.S., 1900); (7) Raith (J.H.B.); (8) Dunfermline (A.C.C.).

R. rubrum L. (*Red Currant*)

In woods and hedges. Not native.

(4) Roadside near Largo (C.G.); (7) Dysart Woods (J.H B.); Dunnikier (A.H.G.); (8) Aberdour (Sonn.); Culross (A.R.).

R. nigrum L. (*Black Currant*)

Woods and hedges. Not native.

(3) East Neuk (W.); (4) Balcarres Den (C.G.); Kilconquhar (J.H.B., 1859; W.Y., 1921); (7) Bogie, near Kirkcaldy (A.H.G.); (8) Morton Woods, Aberdour (W.L.L.).

CRASSULACEAE.

Sedum Linn.

S. roseum Scop. (*S. Rhodiola* DC.) (*Rose-root*)

Native. Extremely rare. Wet rocks.

(1) Balmerino (J.C.); (9) Lomond Hills (B. & S.).

S. Telephium L. (*Orpine, Livelong*)
Fields and stony waste places. Rare. No doubt some of these records belong to *S. purpureum* Tausch.
(1) Lindores Loch (A.L.); Newburgh (G.S.); Balmerino (W.G.S.); Birkhill Woods (R.S.); Newport (W.G.S.); Kilmany (G.S.); (2) Collessie, Cults, by River Eden, Strathmiglo (B. & S.); (5) near Leslie (W.A.); (7) Dysart (B. & S.); Kirkcaldy (W.Y.); Burntisland; (8) St. David's, Port Laing, and Ferry Hills (A.R.); Inverkeithing (J.H.B.); near Charlestown (J.H.B.).
First record: Greville, Inverkeithing, leg. Arnott.

S. purpureum Tausch (*S. Fabaria* Koch)
(9) Kinross (J.R.M.).

S. villosum L. (*Hairy Stonecrop*)
Wet hilly districts. Rare.
(2) Cults (N.S.A.); E. Lomond Hill (W.W.E., 1836); (8) Inverkeithing (K.N.S., 1836); Ferry Hills and Loch Hillhead (A.R.); Knock Hill, near Charlestown, and Saline Hills (J.H.B.); (9) Cleish Hills (A.R.); Lomond Hills (Reid, 1837, R.B.G.) (J.H.B., 1855) (W.Y., 1916).

S. album L. (*White Stonecrop*)
Walls and rocks. Not common.
(4) Balcarres Craig (W.); (5) near Markinch (W.Y.); (7) north of Kirkcaldy 1½ miles (Knapp, 1837); Raith (B. & S.); (8) N. Queensferry (K.N.S., 1837).

S. dasyphyllum L. (*Thick-leaved White Stonecrop*)
Damp rocks and walls. Very rare.
(3) Fifeness (L. & S. and W.). Not seen there for many years.

S. anglicum Huds. (*English Stonecrop*)
(3) Crail (M., & B.); Isle of May and Barnsmuir (G.S.); Kilrenny parish (N.S.A.); between Anstruther and Elie (J.H.B.); (4) Balcarres Craig (W.); (8) Culross (K.N.S., 1836).
First record: Greville, Isle of May, 1825.

S. acre L. (*Yellow Stonecrop, Wall Pepper*)
Walls, rocks, and dry places. Very common.
First record: Sibbald, Inchkeith, as "*Sedum minus.*"

S. reflexum L. (*Crooked Yellow Stonecrop*)
Walls and rocks. Rare.
(1) Lindores Abbey (A.L.); Balmerino (J.C.); Logie (N.S.A.); (2) Cupar (J.H.B.); St. Andrews (B.); (3) Balvaird Castle, near Elie (J.H.B.); (6) Cameron Bridge (A.C.C.); (7) Grange Quarry, Burntisland (B.) (W.E.E., 1907); (8) Inverkeithing (A.R.) (Wallich, 1834).

S. stoloniferum S. T. Gmel. (*S. spurium*)
Casual.
(7) Pettycur (May 1921, R.B.G.).

Sempervivum Linn.

S. tectorum L. (*House-leek*)
On roofs and wall-tops. Not native.
(1) Balmerino (J.C.); Hatton Hill, Newburgh (A.L.); (3) East Neuk (W.); (7) Kirkcaldy (W.Y.); (8) Inverkeithing (J.H.B.).

DROSERACEAE.

Drosera Linn.

D. rotundifolia L. (*Round-leaved Sundew*)
Bogs and moist heaths. Frequent.
First record: Sibbald; without locality.

D. anglica Huds. (*D. obovata* Mert. & Koch)
In boggy places. Very rare.
(1) Forgan Bog (R.S., 1893); (8) near Inverkeithing (A.R.); N. Queensferry (K.N.S., 1836); Knock Hill, Dunfermline (R.B.G., 1853).

D. longifolia L. (*D. intermedia* Drev. & Hayne)
Recorded by Trail, without locality, in Top. Bot., but doubtful.

HALORAGACEAE.

Hippuris Linn.

H. vulgaris L. (*Mare's Tail*)
In stagnant water in lochs, ponds, and ditches. Frequent.

Myriophyllum Linn.

M. spicatum L. (*Water Milfoil*)
Ponds and ditches—in non-peaty water. Common.
First record: New Statistical Account, (9) Orwell.

M. alterniflorum DC.

Ponds and ditches—in peaty water. Rare.

(1) Lindores and Black Lochs (G.W.); (2) Tents Muir (C.H.); (3) Bye-burn, Crail (G.S.); (7) ditch at Balwearie (A.H.G.); (9) Loch Leven (Sonn.).

Callitriche Linn.

C. palustris L. (*C. vernalis* Koch, *C. verna* L., *C. aquatica* Sm.)

Ponds and slow streams. Not common.

(1) Balmerino (J.C.); (2) Ceres (G.S.); Kinkell Braes (J.H.W.); Tents Muir (R.S.); (3) Kenly Burn (G.S.); Isle of May (G.W.); (4) near Colinsburgh (W.); (7) Dunnikier Pond (A.H.G.); (8) Inverkeithing (K.N.S., 1837); Ferry Hills (W.L.L.).

C. stagnalis Scop. (*C. platycarpa* Kuetz.).

Ponds and slow streams. Common.

(1) Lindores and Morton Lochs (G.W.); (3) Pitcorthie Burn (G.S.); Isle of May (G.W.); (4) Hatton Reservoir; near Kilconquhar (W.E.E., 1903); (8) Inverkeithing (J.H.B.); N. Queensferry and Kincardine (B. & S.).

C. intermedia Hoffm. (*C. hamulata* Kuetz.)

(1) Morton Loch (G.W.); (2) Ladybank (F.M.W.); (3) Sauchope Links; Crail (G.S., 1889, certified by C. C. Babington); (6) River Ore (A.H.G.); (7) Balmuto (J.B.S.).

C. autumnalis L.

In slow waters. Frequent.

(1) Lindores Loch (G.S.); Lochmill (G.W.); (4) Kilconquhar Loch (G.W.); (6) Loch Gelly (G.W.); (7) Kinghorn Loch (B. & S.); Burntisland Reservoir (G.W.); (8) Otterston Loch (K.N.S., 1837, and W.E.E., 1905–8).

LYTHRACEAE.

Peplis Linn.

P. Portula L. (*Water Purslane*)

Damp places. Infrequent.

(1) Lindores Loch (C.G.); near Tayport (R.S.); (2) near Ladybank (F.M.W.); Earlshall (R.S.); Tents Muir (M.); (5) Ballo Reservoir (G.W.); (7) near Kirkcaldy; (8) Dunfermline (N.S.A.); (9) Orwell (N.S.A.).

Lythrum Linn.

L. Salicaria L. (*Purple Loosestrife*)
Wet ditches, banks of streams, etc. Uncommon.
(1) Lindores Loch (A.L.); Mugdrum (L. & S.); (2) by River Eden, Collessie parish (N.S.A.); (4) Muircambus, near Kilconquhar (W.); (6) Loch Gelly (Sonn.); (8) near Dunfermline (A.D., 1840); (9) near Cleish (A.R.).

ONAGRACEAE.

Epilobium Linn.

E. angustifolium L. (*Rosebay Willow-herb*)
Moist banks and margins of woods. Common.
Note.—This plant was once considered rather rare, but since 1914 it has increased enormously all over the county, chiefly owing to large areas being denuded of trees.

E. hirsutum L. (*Great Hairy Willow-herb*).
Wet places and by streams and ditches. Common.

× **montanum**, (7) Kirkcaldy (W.Y.).

× **parviflorum**, (2) Rankeilour (W.Y., 1889).

E. parviflorum Schreb.
Among bushes in woods and damp localities.
(1) Balmerino (J.C.); Abbey Burn, Newburgh (A.L.); (2) Calais Moor and Tents Muir (R.S.); Kinkell Braes (J.H.W.); (3) West Braes, Crail (G.S.); Charleton Woods (C.G.); (4) Kilconquhar (J.H.B.); (7) Kirkcaldy (W.Y.); (8) Dalgety (A.C.C.); Rosyth (R.S.).

E. montanum L. (*Broad-leaved Willow-herb*)
Common everywhere.
First record: Greville, N. Queensferry, 1836.

E. roseum Schreb. (*Pale Smooth-leaved Willow-herb*)
Moist places. Uncommon.
(2) Tents Muir (B.); (4) Largo (B.); (8) Inverkeithing (M.) (W.E.E., 1907); St. David's (A.D.); Dunfermline parish (N.S.A.).

E. tetragonum Curt. (*Square-stalked Willow-herb*)
Banks of streams. Uncommon.
(1) Lindores Loch (G.W.); Balmerino (J.C.); (2) Tents Muir (R.S.); Kinkell Braes (J.H.W.); (3) East Neuk (W.);

(4) Balcarres Den (N.S.A.); Kilconquhar Loch (G.W.); (8) near Otterston (W.E.E., 1906); near Inverkeithing (M.).

E. obscurum Schreb. (*Obscure Willow-herb*)

Moist places. Rare.

(3) Toldrie, near Crail (G.S.); (7) Kirkcaldy (W.Y.); Balmuto (J.B.S., 1874, R.B.G.).

E. palustre L. (*Narrow-leaved Marsh Willow-herb*)

Bogs and marshy places. Very common.

E. alsinefolium Vill.

Marshy places on hills. Very rare.

(2) West Lomond (J.H.B., 1855); (8) N. Queensferry (J.H.B., 1860); "Fife," J. Cruickshank, 1837.

E. anagallidifolium Lam. (*E. alpinum* L.)

Marshy places on hills. Very rare.

(2) West Lomond (B. & S.); (9) Glen Queich (B. & S.).

Oenothera Linn.

O. biennis L. (*Evening Primrose*)

Casual.

(7) Waste ground at Pettycur (W.E.E., 1907).

Circaea Linn.

C. lutetiana L. (*Enchanter's Nightshade*)

Woods, hedges, etc. Frequent.

C. alpina L. (*Alpine Enchanter's Nightshade*)

Woods, etc. Very rare.

(2) Maspie Den, Falkland (C.G.); (9) Carnbo (D.); rivulet near Crook of Devon (A.R.); Rumbling Bridge (J.H.B., 1863); Lomond Hills (B. & S.).

LOASACEAE.

Mentzelia Plum.

M. albicaulis Dougl.

Casual.

(7) Burntisland, 1905.

UMBELLIFERAE.

Hydrocotyle Linn.

H. vulgaris L. (*Marsh Pennywort*)

Damp moors and meadows. Common.

Eryngium Linn.

E. maritimum L. (*Sea-holly*)

Sandy seashores. Very rare.

(2) St. Andrews (Hooker); (4) Kincraig (N.S.A.); (7) Burntisland (B. & S.); Largo (Lightfoot), now extinct.

First record: Sibbald, " coast."

Sanicula Linn.

S. europaea L. (*Wood Sanicle*)

In damp woods and rocky dens. Frequent.

(1) Lindores Abbey (A.L.); Balmerino (J.C.); near Wormit (W.G.S.); (2) Maspie Den (R.S.); Dura Den (J.H.W.); (3) Mount Melville Woods (J.H.W.); (4) Keil's Den (M.); Balcarres Woods (C.G.); (6) Lochgelly Woods (W.L.L.); (7) Wemyss Woods (A.H.G.); Kinghorn (W.Y.); (8) Lethan's Glen (A.R.).

Conium Linn.

C. maculatum L. (*Hemlock*)

Banks and hedges. Common.

Smyrnium Linn.

S. Olusatrum L. (*Alexanders*)

Waste places. Rather local, but plentiful where it occurs.

(3) Pittenweem Priory (W.) (J.H.B.); (4) Kincraig (N.S.A.); Largo (W.); (7) Macduff Castle, Ravenscraig Castle, and Kinghorn (W.Y.); Wemyss Castle (Knapp, 1843); Kirkcaldy (Greville, R.B.G.); (8) N. Queensferry.

First record: Hooker, Ravenscraig Castle.

Apium Linn.

A. graveolens L. (*Wild Celery, Smallage*)

Ditches and damp pastures. Very rare.

(8) St. David's (A.C.C , 1869); Charlestown (B. & S.); near Torryburn (J.H.B., 1860); Culross (A.R., 1834); Kincardine (J.H.B., 1863).

Professor Trail thinks this plant a casual or escape.

A. nodiflorum Reichb. fil. (*Procumbent Marshwort*)

Moist places. Very rare.

(2) Tents Muir (Millar). The only record.

var. e. **repens** Koch

(7) Kinghorn Loch (G.W.).

A. inundatum Reichb. fil. (*Water Honewort*)

Ponds and ditches. Uncommon.

(1) Lochmill Loch (G.W.); (2) near Ladybank (F.M.W.); Tents Muir (R.S.); (3) Isle of May (G.S.); (5) Balbirnie, Markinch (G.S.); (7) Kirkcaldy (W.Y.); Kinghorn Loch (G.W.); (8) marsh east of Dalgety Church, Inverkeithing (L. & S.); near Dunfermline (G.W.) (M'Nab, 1836).

Cicuta Linn.

C. virosa L. (*Cowbane*)

Ponds and ditches. Rare.

(1) Lindores Loch (A.L.), extinct; Abdie parish (N.S.A.); (2) Cult Mill (N.S.A.); (4) Kilconquhar Loch (N.S.A.); (8) Lochhead Loch (A.D.); Inverkeithing (N.S.A.); Otterston Loch (A.R.); Black Loch and Knock Hill (J.H.B.); (9) Powmill.

First record: Hooker, Otterston Loch.

Carum Linn.

C. Petroselinum Benth. et Hook. fil. (*Parsley*)

Escape or casual.

(3) Crail (G.S.), "introduced"; (4) Kilconquhar (J.H.B.); (7) near Dysart (George Don, Brodie's Herbarium, R.B.G.); Burntisland near railway station (A.H.G., 1883, R.B.G.); (8) near Inverkeithing (W.L.L.); Ferry Hills (A.R., 1834); Charlestown (A.C.C.); Culross (J.H.B.).

C. segetum Benth. et Hook. fil.

Damp calcareous fields and near the sea. Casual.

(8) Charlestown (A.C.C., Aug. 1867).

C. Carvi L. (*Caraway*)

Garden escape.

(1) Balmerino (J.C.); (3) Crail (W.Y); (7) Burntisland (J.H.B.) (Neill Fraser); (8) St. David's (K.N.S.); N. Queensferry and Dunfermline (B. & S.); Culross and Kincardine (J.H.B.); (9) Kinross (B. & S.).

Sium Linn.

S. latifolium L. (*Broad-leaved Water-parsnip*)

River-sides, ditches. Records probably belong to *S. erectum* Huds.

(1) Scotscraig (W.G.S., Oct. 1884); (2) Leuchars (L. & S.); (4) Kilconquhar Loch (W.); Balcarres Den (N.S.A.).

S. erectum Huds. (*S. angustifolium* L.) (*Narrow-leaved Water-parsnip*)
Wet meadows.
(2) Kinkell and near St. Andrews (G.S.); (4) Kilconquhar Loch (G.S.); Largo Links (Knapp, 1837); Balcarres Den (N.S.A.); (7) Kinghorn Loch (G.W.); Burntisland (N.S.A.).

Aegopodium Linn.

A. Podagraria L. (*Goatweed, Bishopweed*)
Damp places. Very common everywhere.

Pimpinella Linn.

P. Saxifraga L. (*Burnet Saxifrage*)
Dry pastures, rocks, and hills. Frequent.

var. c. **dissecta** N.E.Br.
(3) Crail (1885) and Dunino (G.S., 1896).

P. major Huds. (*Greater Burnet Saxifrage*)
Shady places. Very rare. Records probably belong to *P. Saxifraga* L.
(3) Near Crail (G.S., 1885), Kilrenny (W.); (4) Cockle Mill Burn (G.S.).

Conopodium Koch

C. majus Loret (*C. denudatum* Koch, *Bunium flexuosum* L.)
Sandy and gravelly pastures. Common.

Myrrhis Scop.

M. Odorata Scop. (*Sweet Cicely*)
Waste places. Common.

Chaerophyllum Linn.

C. temulum L. (*Rough Chervil*)
Hedge-banks, roadsides. Common.

Scandix Linn.

S. Pecten-Veneris L. (*Shepherd's Needle*)
Fields and waste places. Not common.
(1) Newburgh (J.H.B.); (2) Tents Muir (A.C.C.); St. Andrews (J.H.W.); (3) Crail (W.Y.); (4) fields on Largo Law, Balcarres (C.G.); (7) Burntisland (J.H.B.); (8) near Otterston (W.E.E., 1903); Inverkeithing (A.C.C.); Ferry Hills (K.N.S., 1836).

S. iberica Bab.
Alien.
(7) Burntisland (J.F., 1906, A.S.N.H.).

Anthriscus Bernh.

A. vulgaris Bernh. (*Beaked Parsley*)
Roadsides, hedges, and waste places. Common.

A. sylvestris Hoffm. (*Wild Chervil*)
Borders of fields and hedge-banks. Frequent.
(1) Balmerino (R.S.); (2) near St. Andrews (J.H.W.); (3) Cambo (G.S.); (4) Balcarres Den (W.); (7) near Kirkcaldy (A.H.G.); (8) Aberdour (W.L.L.); (9) Kinross (J.H.B. & R.S.).

A. Cerefolium Hoffm. (*Garden Chervil*)
Hedges and roadsides. A garden escape.
(7) Kirkcaldy (W.Y.).

Foeniculum Hill

F. vulgare Mill. (*Fennel*)
Rocks and waste places near the sea. Uncommon.
(4) Kilconquhar (J.H.B.); (8) St. David's (W.Y.); Charlestown (A.C.C.).

Crithmum Linn.

C. maritimum L. (*Samphire*)
Rocky seacoasts.
Probably extinct long ago, as Greville in 1824 said "Not now recorded in Isles of Firth of Forth." Professor Trail recorded it in A.S.N.H. as "doubtful."

Oenanthe Linn.

O. fistulosa L. (*Water Dropwort*)
By ponds and ditches. Very rare.
(8) Near Dunfermline (J. R. Reid, R.B.G., n.d.).
First record: Lightfoot, "between Inverkeithing and N. Queensferry."

O. crocata L. (*Hemlock Dropwort*)
By ponds and ditches. Frequent.
(1), (2), (3), (4), (8).
First record: Greville, (8) "near Limekilns," Neill.

O. aquatica Poir. (*O. Phellandrium* Lam.)
Ditches, ponds, marshes. Very rare.
(2) Near Ladybank (J. Sadler, 1876, R.B.G.); (8) Charlestown (A.C.C., 1871).

Aethusa Linn.

A. Cynapium L. (*Fool's Parsley*)
Fields and cultivated places. A colonist. Common.

Silaus Bernh.

S. flavescens Bernh. (*S. pratensis* Bess.) (*Meadow Pepper Saxifrage*)
Pastures and meadows.
(3) Elie (Sonn.); Pitcorthie (G.S., Sept. 1896).

Meum Hill

M. athamanticum Jacq. (*Bald-money*)
Dry hills and pastures. Rather rare.
(4) Lathones (M.); Largoward Coalpits (W.); (7) Kinghorn (N.S.A.); (8) near Dunfermline (J.H.B.); (9) Cleish (A.R.); Crook of Devon (R.B.G.); Glen Queich (B. & S.); Orwell parish (N.S.A.).

Ligusticum Linn.

L. scoticum L. (*Scottish Lovage*)
(2) Tents Muir (J.H.B.); Kinkell Braes (J.H.W.); (3) Crail (W.Y.); Isle of May (Greville & G.W.); near Elie (F.M.W.); near Anstruther (Dr. Graham); (4) Kilconquhar (J.H.B.); (7) between Dysart and Kirkcaldy (W.W.E., 1840); Kirkcaldy (W.Y., single plant); Dysart (B. & S.); Pettycur (J.B.S.); Inchkeith (A.H.G.); (8) Aberdour (A.C.C.); St. David's (P.N.F.).
First record: Lightfoot, "between E. & W. Wemyss and Kinghorn."

Angelica Linn.

A. sylvestris L. (*Angelica*)
Damp woods and marshy places. Frequent.
(1), (2), (3), (4), (7), (8), (9).

Archangelica Hoffm.

A. officinalis Hoffm.
Introduced. Watery places. Rare.

(3) Near Elie and Anstruther (J.H.B., 1864); (9) Rumbling Bridge (J.H.B., 1863).

Peucedanum Linn.

P. Ostruthium Koch. (*Hog's Fennel*)

Waste places. Rare. Introduced.

(3) Elie (J.H.B.); (7) near Auchtertool (A.R., 1835, R.B.G.); Dunearn Hill and Balmuto (J.H.B.); near Burntisland (E. Young, 1838); (8) Aberdour (1837); Dunfermline (B. & S.); (9) Cleish (A.R.), 2 miles north of Milnathort (Maughan).

First record: Sibbald, no locality, as "*Imperatoria Ostruthium.*"

P. sativum Benth. et Hook. (*Wild Parsnip*)

Banks on calcareous soil. Casual. Rare.

(2) Near St. Andrews (Dr. Balfour); (3) Crail (W.Y.); (8) St. David's (W.E.E., 1902); near Inverkeithing (W.L.L., 1849); near Kincardine (A.D., 1835).

Heracleum Linn.

H. Sphondylium L. (*Cow-parsnip, Hogweed*)

Hedge-banks and roadsides. Common.

Coriandrum Linn.

C. sativum L. (*Coriander*)

Waste places. Scarcely naturalised. Very rare.

(8) St. David's (Dr. Wallich and A.R., 1834) (A.C.C., 1867 and 1885).

Daucus Linn.

D. Carota L. (*Wild Carrot, Bird's Nest*)

Pastures, banks, etc. Not common.

(1) Clachard (A.L.); Balmerino (J.C.); near Newport (W.G.S.); near St. Andrews (J.H.W., 1858); (3) Crail (G.S.); (4) Kincraig (W.); Largo Law (B.); (7) Chapel Quarry (W.Y.); near Kinghorn (W.Y.), Balwearie (A.H.G.); Burntisland (J. Knapp); near Wemyss (C.G.); (8) Aberdour (A.C.C.); St. David's (J.H.B.); Inverkeithing (K.N.S., 1832); N. Queensferry (B. & S.); Pitreavie and Charlestown (R.S.).

Caucalis Linn.

C. arvensis Huds. (*Torilis infesta* Rchb.) (*Hedge Parsley*)

Fields, roadsides. Very rare.

(3) East Neuk of Fife (W.); (4) Balcarres, by roadside (C.G.).

C. Anthriscus Huds. (*Torilis Anthriscus* Gaert.)
Waysides, hedges. Very common.
First record: Inverkeithing (K.N.S., 1836).

C. latifolia L.
Casual.
Only record is by A. Craig Christie (1871), without locality.

C. nodosa Scop. (*Torilis nodosa* Gaert.)
Banks and dry places. Very rare.
(2) St. Andrews (D.-H., 1866); (3) Crail (G.S.); Colinsburgh (C.G.); (7) between Kinghorn and Burntisland (J.H.B., 1846); (8) Ferry Hills and Inverkeithing (A.R.).

ARALIACEAE.

Hedera Linn.

H. Helix L. (*Common Ivy*)
Rocks, walls, trunks of trees. Very common.

CORNACEAE.

Cornus Linn.

C. suecica L. (*Wild Cornel*)
Moist alpine moors. Introduced.
(8) Pitreavie and Culross (A.R.).

C. sanguinea L. (*Dogwood*)
Hedges and woods. Very rare.
(3) Elie Woods (G.S., 1891), probably introduced; (8) near Torryburn (A.T., 1919).

CAPRIFOLIACEAE.

Adoxa Linn.

A. Moschatellina L. (*Moschatel*)
Woods and shady places. Very rare.
(1) Woodhaven, near Newport, Ballinbreich Castle (J.C.); (2) Kinkell Braes (J.H.W. & R.S.); (3) near Crail (W.Y.); (4) Balcarres Den (W.); (5) Balmalcolm Den (C.H.); (7) Raith, Kirkcaldy (W.Y.); Auchtertool (A.C.C.); Burntisland (J.H.B.); (8) Inverkeithing (N.S.A.); Fordel, Woodmill, and Culross (A.R.); (9) Cleish and Lomond Hills (C.H.).

Sambucus Linn.

S. nigra L. (*Common Elder*)

Woods and hedges. Common.

var. b. **laciniata** Mill.

(7) Wemyss Castle Rocks (J.H.B., 1856).

S. Ebulus L. (*Dwarf Elder*)

Woods and waste places. Doubtful native. Rare.

(2) Edenshead (L. & S.); near Kinloch and Collessie parish (N.S.A.); (7) Auchtertool (A.R.); (8) St. David's and Inverkeithing (A.R.); (9) Cleish (A.R.).

First record: Sibbald, "Inchcolm (garden)," as "Dwarf-elder."

Viburnum Linn.

V. Opulus L. (*Common Guelder Rose*)

Hedges, woods. Introduced. Rare.

(4) Near Largo (J. Knapp, 1843, R.B.G.); (8) Dhu Craig, Culross, and Lethan's Glen (A.D. & A.R., "all truly indigenous"); (9) Rumbling Bridge (J.H.B.).

V. Lantana L. (*Mealy Guelder Rose*)

(3) Elie Woods (Wood); (4) Kilconquhar Woods (J.H.B.); (7) Dysart Woods (J.H.B.).

Lonicera Linn.

L. Caprifolium L. (*Honeysuckle*)

Woods and thickets. Rare.

(3) Buddo Rock and Crail's Muir (G.S.); Elie Woods (W.); (7) Dysart Woods (J.H.B., 1847).

L. Periclymenum L. (*Woodbine, Common Honeysuckle*)

(1), (2), (3), (6), (7), (8), (9).

L. Xylosteum L. (*Upright Fly Honeysuckle*)

Woods and thickets. Very rare.

(7) Begg Woods, Kirkcaldy (A.H.G.); (8) Inverkeithing (J.H.B.); near Dunfermline (Dr. Dewar, Trans. Bot. Soc. Edin.).

RUBIACEAE.

Galium Linn.

G. boreale L. (*Cross-leaved Bedstraw*)

Moist rocky places. Very rare.

(2) W. Lomond Hill (B. & S.); (4) By Kilconquhar Loch—

ditch (W.); (9) Lomond Hills (M., and B.); Bishop Hill (J.H.B.).

G. Cruciata Scop. (*Crosswort, Mugwort*)
Borders of fields, roadsides, and banks. Very common.

G. verum L. (*Yellow Bedstraw*).
Dry banks and pastures. Common.

G. erectum Huds.
Banks and pastures.
Only record is from (2) Cults parish "close to mill-dam opposite Crawford Priory Garden" (B. J. Heriot). But see record under *G. Mollugo* from same locality.

G. Mollugo L. (*Great Hedge Bedstraw*)
Hedges, etc. Rare. May include *G. erectum* Huds.
(2) Cults (M.); (3) near Crail (G.S.); (7) Pettycur (R.S.); (8) St. David's and Pitreavie (R.S.); Dunfermline parish (N.S.A.); Kincardine (K.N.S.).

G. saxatile L. (*Smooth Heath Bedstraw*)
Heathy pastures. Very common.

G. asperum Schreb. (*G. sylvestre* L., *G. pusillum* Sm.)
Hilly pastures. Uncommon.
(1) Balmerino (R.S.); (3) St. Monans Burn (W.); (4) Dunbarnie Links (W.); (9) Lomond Hills (J.H.B.).

G. palustre L. (*White Water Bedstraw*)
Sides of ditches and ponds. Common.
var. **Witheringii** (Sm.)
(9) Orwell (W.A.).

G. uliginosum L. (*Rough Marsh Bedstraw*)
Wet places. Frequent.
(2), (3), (4), (7), (8), (9).

G. Aparine L. (*Goosegrass, Cleavers*)
Hedges and waste places. Very common.
First record: Sibbald, "Inchkeith," as "*Aparine*."

G. cinereum (Sm.) (*G. diffusum* Hook.)
(2) Mill-dam off Priory Garden, Cults (N.S.A.).
A doubtful native and very rare.

Asperula Linn.

A. odorata L. (*Sweet Woodruff*)

Woods and shady places. Widely distributed.

(1) Fincraig, Newburgh (A.L.); Balmerino (J.C.); Birkhill (R.S.); St. Fort (W.G.S.); (2) Maspie Den (R.S.); Dura Den (C.G.); (3) Cambo (R.S.); (4) Largo Law (M.); Balcarres Den (N.S.A.); (7) Raith (A.H.G.); Auchtertool Linn (W.L.L.); Burntisland (L. & S.); (8) Aberdour (J. R. Reid); Inverkeithing and N. Queensferry (J.H.B.); (9) Orwell parish (N.S.A.).

A. taurina L.

Introduced.

(2) Cupar (Barclay, 1861); (7) near Burntisland (J.H.B., 1856).

A. arvensis L.

(7) Waste ground, Burntisland Docks (W.E.E., 1907).

Sherardia Linn.

S. arvensis L. (*Field Madder*)

Fields, pastures, gardens. Common.

var. **mutica** Wirtg.

(7) Sandy ground, Pettycur (W.E.E., 1906).

VALERIANACEAE.

Valeriana Linn.

V. dioica L. (*Small Marsh Valerian*)

Marshy places. Rather rare.

(2) Rankeilour (W.Y.); (4) Dunbarnie Links (W.Y.); (6) Thornton (M.); Kennoway (B. & S.); (9) Bishop Hill (W.Y.).

V. sambucifolia Mikan

Common. The records of *V. officinalis* no doubt refer to this species.

(1) River-bank near Ballinbreich, and den at west end of Lochmill (A.L.); (3) Kenly Den (G.S.); Saughur (W.); (7) Balmuto (J.B.S.).

V. pyrenaica L. (*Heart-leaved Valerian*)

Woods, banks of rivers. Introduced. Rare.

(1) Balmerino (J.C.); (2) Claremont Den, near St. Andrews

(B.); (7) Wemyss Castle Rocks (J.H.B.); Dysart (B. & S.); Raith (W.Y.); (9) Cleish (A.R.); near Blairadam (R.B.G.).

First record: Blairadam, no collector, 1782 (R.B.G.).

Kentranthus Neck.

K. ruber DC. (*Red Valerian*)

Rocks and old walls. Not a native.

(2) Banks of Eden near Cupar; (4) near Elie (J. Knapp, R.B.G.); (7) Kinghorn (B. & S.); Burntisland (W.Y.); (8) Donibristle (J.H.B.); St. David's (A.R.); Inverkeithing (B. & S.).

First record: St. David's, Rev. A. Robertson, 1835 (R.B.G.).

Valerianella Hill

The records for the rarer species of this difficult genus need verification.

V. olitoria Poll. (*Corn Salad, Lamb's Lettuce*)

On banks and in cornfields. Frequent.

(1), (2), (3), (4), (7), (8).

V. eriocarpa Desv. (*Rough-fruited Corn Salad*)

Cornfields and banks. Very rare.

(8) Near N. Queensferry, 1837 (M.) and (B. & S.).

V. carinata Lois.

Very rare.

(8) Aberdour (J. R. Reid, 1877, R.B.G.).

V. rimosa Bast. (*V. Auricula* DC.)

Cornfields. Very rare.

(2) St. Andrews (B.); (4) Largo (B.) and (W.); (8) North Queensferry (G. M'Nab); Ferry Hills (K.N.S.).

First record: N. Queensferry, 1836, G. M'Nab (R.B.G.).

V. dentata Poll. (*Smooth Narrow-fruited Corn Salad*)

Cornfields and banks. Not common.

(1) Balmerino (J.C.); (7) Raith, Kirkcaldy (B. & S.): Balmuto (W.Y.); near Kinghorn (R.B.G.); Burntisland (J.H.B.); (8) Inverkeithing (M.); N. Queensferry (K.N.S.); near Torryburn (J.H.B.); Limekilns (B. & S.).

First record: Hooker, " near Kirkcaldy," as "*Fedia dentata.*"

var. **mixta** (Dufr.)

(7) Pettycur (W.E.E., 1906); (8) near Inverkeithing (K.N.S. and Dr. Dewar, 1837); Dunfermline parish (N.S.A.).

DIPSACACEAE.

Dipsacus Linn.

D. sylvestris Huds. (*Wild Teasel*)

Waste places, hedges. Rather rare.

(1) Newburgh—glebe (R.B.G.); Mugdrum Woods (A.L.); (7) Wemyss and Dysart (W.Y.); Kinghorn and Burntisland (B. & S.); (8) Donibristle and Inchcolm (A.R.); Charlestown (A.R.); Limekilns (J.H.B.); (9) Orwell (N.S.A.).

First record: Lightfoot, "Lord Elgin's Limeworks, near Dunfermline," as "*D. fullonum.*"

D. pilosus L. (*Shepherd's Rod*)

Moist shady places. Introduced. Very rare.

(1) Flisk (no data, R.B.G.); glebe at Newburgh (L. & S.).

Scabiosa Linn.

S. Succisa L. (*Devil's Bit Scabious*)

Meadows, banks, and pastures. Common.

White-flowered variety. (9) Orwell parish (N.S.A.).

S. arvensis L. (*Knautia arvensis* Coult.)

Fields, pastures, roadsides. Common.

First record: Sibbald, "Inchkeith," as "Scabious."

Smooth variety on (2) Ballomill and Cults Hills (R.B.G.).

White-flowered variety. (4) Largo (J. Knapp, 1843).

COMPOSITAE.

Eupatorium Linn.

E. cannabinum L. (*Hemp, Agrimony*)

Banks of streams and waste places. Not common.

(1) Balmerino (J.C.); Wormit (R.S.); (4) Kincraig (N.S.A.); (7) Ravenscraig (A.H.G.); Auchtertool Linn and Kinghorn (W.Y.); Burntisland (G. Don, n.d., R.B.G.); (8) Starleyburn and near St. David's (A.R.); Aberdour (E. Young, 1837, R.B.G.) and (A.C.C., 1865).

First record: Lightfoot, "among the rocks below Kinghorn, Dr. Parsons."

Solidago Linn.

S. Virgaurea L. (*Golden Rod*)

Woods and thickets. Frequent.

(1), (2), (3) (7), (8), (9).

Bellis Linn.

B. perennis L. (*Daisy*)
Common everywhere.

Aster Linn.

A. Tripolium L. (*Michaelmas Daisy, Sea Starwort*)
Muddy salt marshes. Frequent.
(1), (2), (3), (4), (7), (8).
First record: Greville, "Sea mill-dam, Burntisland Bay."

Erigeron Linn.

E. canadense L. (*Canadian Flea-bane*)
Waste ground. Casual. Very rare.
(1) Tayport—ballast heaps (G. Law, 1858); (4) Balcomie (G.S.); (8) St. David's and Charlestown (A.C.C., 1870 71).

Filago Linn.

F. germanica L. (*Filago, Impious Weed*)
Sandy places. Not common.
(1), (2), (4), (7), (8), (9).

F. minima Fr. (*Least Filago*)
Sandy and gravelly places. Rare.
(1) Mare's Craig (A.L.), Balmerino (J.C.): Scotscraig (W.G.S.); near Newport (J. Knapp); (2) Tents Muir (A.C.C.); St. Andrews; (3) Craighead Quarry (G.S.); (7) near Kirkcaldy (W.Y.).

F. gallica L.
Casual.
(1) Near Newburgh (D. Don and Hooker); (2) St. Andrews Links (C.H.).

Antennaria Gaertn.

A. dioica Gaertn. (*Cat's Foot*)
Dry heathy pastures. Not common.
(1) Ormiston Hill (A L.); Norman's Law (G.S.); (2) near Falkland, Edensmuir, and Cults parish (N.S.A.); Tents Muir (M.); St. Andrews (J.H.W.); Drumcarro Crag (M.); (5) Markinch (A.C.C.); (6) Cardenden (W.W.E., 1840); (8) N. Queensferry (A.R.); Knock Hill (J.H.B.); Inverkeithing (A.R.); (9) Lomond Hills (J.H.B.); Orwell (W.A.).
First record: Greville, "Hills above North Queensferry" as "*Gnaphalium dioicum.*"

Gnaphalium Linn.

G. uliginosum L. (*Marsh Cudweed*)
Wet sandy places. Frequent.
(1), (2), (4), (7), (8), (9).

G. sylvaticum L. (*Highland Cudweed*)
Woods and heathy pastures. Frequent.
(1), (2), (4), (7), (8), (9).

G. supinum L. (*Dwarf Cudweed*)
Alpine districts. Very rare.
(1) Newburgh (N.S.A.); Norman's Law (L. & S.); (9) Orwell parish (Dr. Arnott).

Inula Linn.

I. Helenium L.
Moist pastures. Introduced. Very rare.
(2) Near Bunzeon, Cults parish; (7) hills east of Burntisland (N.S.A.); (8) near (6 miles) Dunfermline (B. & S.).

Pulicaria Gaertn.

P. dysenterica Gray (*Flea-bane*)
Moist and watery places. Rare.
(3) Near Elie, leg. H. Cleghorn (1837, R.B.G.).

Bidens Linn.

B. cernua L. (*Nodding Bur Marigold*)
Sides of lochs, etc. Rare.
(1) Lindores Loch (A.L.); (4) Kilconquhar Loch (J.H.B. & G.S.); (8) Otterston Loch and near Rosyth Castle (B. & S.); near Inverkeithing (B.), Fordel (A.R.); (9) Orwell parish (N.S.A. & B.).

B. tripartita L. (*Trifid Bur Marigold*)
Marshy localities. Rare.
(1) Drumtenant and Black Loch (B.); (2) Collessie (B.); (4) Kilconquhar Loch (W.); (7) Burntisland Docks (W.E.E., 1902); (8) near Inverkeithing (B.); (9) Orwell parish (B.); Loch Leven (J.H.B.).

Achillea Linn.

A. Millefolium L. (*Yarrow, Milfoil*)
Roadsides, pastures, waste places. Common everywhere.

A. Ptarmica L.
Moist banks and pastures. Frequent.
(1) Lindores Loch (A.L.); Balmerino (J.C.); near St Fort (R.S.); (2) Prior Muir (J.H.W.); (3) Crail (G.S.); (4) near Largo (W.Y.); (8) Aberdour (A.C.C.); (9) Lomond Hills (J.H.B.).

A. nobilis L.
Alien, long established.
(7) Burntisland (W.E.E., 1904).

Anthemis Linn.

A. tinctoria L. (*Ox-eye Chamomile*)
Fields and waste places. Casual.
(8) St. David's (B. & S.).

A. Cotula L. (*Stinking Chamomile*)
Fields and waste places. Not common.
(1) Near Newburgh (B.W.); Tayport (W.G.S.); (2) Cupar and near St. Andrews (J.H.B.); (3) Sypsies Farm (G.S.); between Anstruther and Elie (J.H.B.); Elie Harbour (W.); (8) St. David's (Brand, 1835); Inverkeithing (A.R.); Charlestown and N. Queensferry (B. & S.); near Dunfermline (D.).

A. arvensis L. (*Corn Chamomile*)
Fields and roadsides. Frequent.
First record: Inverkeithing, A. Robertson, 1835.

Chrysanthemum Linn.

C. segetum L. (*Corn Marigold*)
Cultivated fields. Common.

C. Leucanthemum L. (*Ox-eye Daisy*)
Common everywhere.
First record: Sibbald, without locality.

C. Parthenium Bernh. (*Feverfew*)
Waste places. Introduced.
(1) Balmerino (J.C.); (3) Crail (G.S.); Carnbee (W.); (4) near Charleton (C.G.); (7) Dysart and Pettycur (B. & S.); Burntisland (W.Y.); (8) Aberdour Castle (J.H.B.); Dalgety (G.S.); Inverkeithing, Otterston, Fordel, and Culross (A.R.); near Torryburn (J.H.B.).

Matricaria Linn.

M. inodora L. (*Scentless Mayweed*)

Fields and waste places. Common.

First record: North Queensferry, Greville, 1836.

var. **salina** Bab. (var. *maritima* auct. non L.)

Seacoast. Rare.

(1) Seashore near Tayport (G. Laurie, 1859); (2) near St. Andrews (J.H.W.); (3) Crail (W.); (4) near Largo (J.H.B., 1865); (7) Inchkeith (A.H.G., 1883); (8) Inchcolm (Neill).

First record: Inchcolm, Greville.

M. Chamomilla L. (*Common Chamomile*)

Fields and waste places. Not common.

(3) Carnbee (L. & S. and W.); (4) Balcarres (C.G.); (8) St. David's (J.H.B.); near Inverkeithing (A.R., 1832); Dunfermline parish (N.S.A.).

First record: "Fife," George Don, no locality.

M. suaveolens Buchenau (*M. discoidea* DC.)

Waste places and by roadsides and fields.

A recent introduction from N. America which has spread rapidly and is now common everywhere.

Tanacetum Linn.

T. vulgare L. (*Tansy*)

Waste places and roadsides. Common.

Artemisia Linn.

A. Absinthium L. (*Wormwood*)

Waste places. Not common.

(2) St. Andrews (J.H.W.); (3) near Crail (W.Y.); Kilrenny parish (N.S.A.); Elie (A.S.); (4) near Largo (R.B.G.); (7) Dysart (B. & S.); Burntisland (A.R.); (8) Donibristle (Brodie); Inchcolm (B. & S.); N. Queensferry (Greville, 1836); St. David's (J.H.B.).

A. vulgaris L. (*Mugwort*)

By hedges and waste places. Very common.

First record: Sibbald, "coast."

A. campestris L.

Sandy heaths. Introduced. Very rare.

(8) Aberdour, St. David's, and Charlestown (A.C.C., 1865, and W.E.E., 1907).

A. maritima L. (*Sea Wormwood*)

Seashore, in salt marshes. Rare. These records probably include the var.

(1) Newburgh (N.S.A.); Balmerino (N.S.A.); Tayport (C.H.); (3) Barnsmuir, near Crail (G.S.); Isle of May (B.); Anstruther (Miss Goodsir, 1839); (4) Kincraig Point (N.S.A.).

var. gallica Willd.

(3) Near Crail, leg. J. Knapp, Sept. 1836.

Tussilago Linn.

T. Farfara L. (*Coltsfoot*)

Fields and waste places. Very common.

Petasites Hill

P. fragrans Presl (*Scented Butter-bur*)

Woods. Introduced. Rare.

(2) Kinness Burn (J.H.W.); near St. Andrews (B. & S.); (7) Dysart Woods and bank between Kirkcaldy and Kinghorn (W.Y.); Balmuto (J.H.B.); (8) Otterston (J.H.B.); (9) Rumbling Bridge (J.H.B., 1863).

P. ovatus Hill (*P. officinalis* Moench, *P. vulgaris* Desf.) (*Common Butter-bur*)

By sides of streams. Common.

P. albus Gaertn. (*White Butter-bur*)

Damp meadows and sides of streams. Introduced. Rare.

(2) Strathtyrum (J.H.W.); (3) Cambo (G.S.); (7) near Kirkcaldy (W.Y.); Auchtertool (A.R., 1833); Balmuto (A.C.C.); (9) Cleish (Dr. Currer).

Doronicum Linn.

D. Pardalianches L. (*Great Leopard's Bane*)

Damp woods. Not common.

(1) Near Ballinbreich (A.L.); Balmerino (A.C.); St. Fort Woods and Newport (R.S.); (2) Cupar (J.H.B.); (4) near Leven (J. Knapp, 1835, R.B.G., "apparently wild"); (5) Markinch (A.H.G.); (7) Dysart Woods (J.H.B.); Raith (B. & S.); (8) Aberdour (G.S.); Otterston (1837), (A.C.C., 1866); Culross (A.R.); near Torryburn (A.T., 1919). "Truly a native of many moist woods in a clay soil in Fifeshire," D. Don (Eng. Bot. Suppt.).

D. plantagineum L. (*Plantain-leaved Leopard's Bane*)
Damp woods. Introduced. Not common.
(4) Largo House (B. & W.); (7) Dysart Woods (W.Y.); Raith and Burntisland (B. & S.); (8) near Kincardine (J.H.B.); Saline; (9) Cleish Woods (A.R., 1839); Kinross Woods (Phyt. II).

Senecio Linn.

S. vulgaris L. (*Common Groundsel*)
Waste ground, fields, gardens. Very common.
First record: Inchkeith, Sibbald, as "*Senecio* or *Ground-swallow.*"

S. sylvaticus L. (*Mountain Groundsel*)
Dry banks, gravelly pastures. Frequent.
(1), (2), (3), (4), (8).

var. **auriculatus** Meyer
(2) Collessie parish (N.S.A., "sparingly").

S. viscosus L. (*Stinking Groundsel*)
Waste ground. Frequent.
First record: Lightfoot, "near salt-works, Leven; Dysart pier and Charlestown Limeworks."

S. erucifolius L.
Alien. Very rare.
(8) St. David's (A.C.C., Oct. 1868); between Aberdour and Burntisland (F. M. Webb, Sept. 1876); near Charlestown (W.E.E., 1904).

S. Jacobaea L. (*Common Ragwort*)
Pastures and waste places. Very common.

S. aquaticus Hill (*Marsh Ragwort*)
Marshy places. Frequent.
(1), (2), (3), (4), (8), (9).

S. sarracenicus L. (*Broad-leaved Groundsel*)
Moist places. Introduced. Rare.
(1) Balmerino (J.C.); (3) Innergellie Woods (W.); (7) Raith (Sonn.); (8) Carnock Moor; Dunfermline (A.D.).

Arctium Linn.

A. majus Bernh. (*A. Lappa* L.) (*Burdock*)
Waste places. Common. Most records of this species doubtless refer to *A. nemorosum* Lej.
First record: Inchkeith, Sibbald.

A. minus Bernh. (*Lesser Burdock*)
Waste places. Rare.
(3) Crail (G.S., 1865); (6) near Thornton (A.H.G.); (7) Dysart (B. & S.); Burntisland (F. M. Webb); (8) St. David's and Charlestown (R.S.).

Carduus Linn.

C. pycnocephalus L., var. b. **tenuiflorus** Curt. (*Slender-flowered Thistle*)
Waste, sandy places. Rare.
(3) Castle Park, Crail (G.S.); near Elie (J.H.B.); Kilconquhar (B. & S.); Kincraig Point (C.G.); (7) near West Wemyss (W.Y.); (8) Inverkeithing (A.R.); St. David's Bay (W.E.E., 1902); N. Queensferry (J.H.B.).

C. nutans L. (*Musk Thistle*)
Waste ground. Not common.
(1) Balmerino (J.C.); (3) Elie Harbour (W.); (4) Kincraig Point (C.G.); Largo Bay (B.); (8) Inverkeithing (B.); N. Queensferry; Limekilns (A.D., 1836).

C. crispus L. (*Crisped Thistle*)
Dry banks, fields, and waste places. Common.
First record: North Queensferry, Greville.
A white form has been found (2) near St. Andrews (B.); (7) near Kirkcaldy (W.Y.).

var. b. **polyanthemos** Koch
(3) Crail (G.S., 1887). Casual.

var. c. **acanthoides** L.
(1) Balmerino (J.C.); (3) Crail (G.S.); (8) St. David's (B. & S.); Aberdour (A.C.C.); near Inverkeithing (A.R.); N. Queensferry and Limekilns (J.H.B.).

Cnicus Linn.

C. lanceolatus Willd. (*Spear Thistle*)
Waste places, pastures, etc. Very common.
A white form is occasionally seen.

C. eriophorus Roth (*Woolly-headed Thistle*)
Waste places. Rare. Casual.
(2) Cults (A.R.); Crawford Priory (N.S.A.) and near St. Andrews (B.); (3) Cambo (W.); Crail (G.S.); (8) N. Queensferry (J.H.B.).

C. palustris Willd. (*Marsh Thistle*)
Marshes and wet meadows. Common.

C. heterophyllus Willd. (*Melancholy Thistle*)
Moist places. Rare.
(3) Near Kingsbarns (W.); near Boarhills (M.); Kenly Burn (B.); (5) near Holl Reservoir (W.Y.); (9) Lomond Hills (J.H.B.).

C. arvensis Hoffm. (*Creeping Thistle*)
Fields, roadsides, etc. Common.

var. d. **setosus** Bess.
Rare.
(1) Tayport (B.); (2) Tents Muir (B.); St. Andrews (B. & S.); (3) Crail (W.Y.); (6) River Ore (A.H.G.); (7) Kirkcaldy (A.H.G.); (8) St. David's (A.C.C.); Dunfermline (B.); near Limekilns (J.H.B.).

Onopordum Linn.

O. Acanthium L. (*Scotch* or *Cotton Thistle*)
Waste ground. Introduced. Rare.
(7) Burntisland (W.E. & W.E.E. 1904); near Kirkcaldy (Stewart n.d.); (8) Inverkeithing (B. & S.), and near Charlestown (Neill); Torryburn (J. Knapp, 1837).
First record: Lightfoot, Wemyss (7).

Silybum Vaill.

S. Marianum Gaertn. (*Milk Thistle*)
Waste places. Casual. Very rare.
(2) Cupar (J.H.B., 1871); (3) Crail (G.S.); east of Elie (J.H.B., 1861); (4) railway banks, Kilconquhar (J.H.B., 1851); (7) near Burntisland (J.H.B., 1855, and A.C.C., 1899); Inchkeith (B. & S.); (8) Inverkeithing and Charlestown (A.R.); Limekilns (Sonn.).
First record: Greville, "between Kirkcaldy and Kinghorn" (7), as "*Carduus marianus*," syn. *Mariana lactea* (Hill).

Centaurea Linn.

C. nigra L. (*Knapweed*)
Pastures and waste places. Very common.
A white form has been found (4) Largo Bay (B.).

C. Scabiosa L. (*Greater Knapweed*)
Cornfields, sandy links on the coast. Uncommon.
(1) Balmerino (J.C.); near Newport (J. M'Nab, 1834, R.B.G.; W.G.S., 1885); (2) Cults parish (N.S.A.); Dairsie (R.S.); St. Andrews (J.H.W.); (3) Elie (A.C.C.); (4) Largo (W.Y.); Kilconquhar (G.S.); Kincraig (W.); (7) Buckhaven (A.H.G.); (8) St. David's (R.S.).
A white form has been found (4) near Elie (W.Y., 1920); Earlsferry (J. Knapp, 1843).

var. **coriacea** (Wald. et Kit.) Koch
Professor Trail (A.S.N.H., 1906).

C. Cyanus L. (*Corn Bluebottle* or *Cornflower*)
Cornfields. Not common.
(1) Balmerino (J.C.); Mare's Craig (A.L.); (2) near Leuchars (W.G.S.); St. Andrews (J.H.W.); (3) Kenly Den (G.S.); (4) Kincraig Braes (W.); Balcarres (C.G.); (7) Burntisland (B. & S.); (9) Lomond Hills (J.H.B.).

Cichorium Linn.

C. Intybus L. (*Wild Succory, Chicory*)
Waste places near gardens. An escape. Rare.
(2) Collessie and Cults parish (N.S.A.); St. Andrews (B.); (3) Crail (G.S.); (4) Largo (W.); Kilconquhar (G.S.); (6) Lochgelly (L. & S.); (7) Burntisland Docks (W.E.E., 1903); (8) St. David's (B. & S.): Inchcolm and Inverkeithing (A.C.C.); Dunfermline (Dr. Dewar and J.B.S.); (9) Kinross (Hook.).
First record: Sibbald, Inchcolm.

Arnoseris Gaertn.

A. minima Schweigg. et Koerte (*A. pusilla* Gaertn.)
(7) Pettycur, waste ground (2 plants) (W.E.E., July 1906).

Lapsana Linn.

L. communis L. (*Nipplewort*)
Waste ground. Very common.

Picris Linn.

P. hieracioides L.
Dry banks. Very rare.
(8) Near St. David's (Dr. Dewar, 1837, R.B.G.

P. echioides L. (*Ox-tongue*)
Dry banks. Very rare.
(4) Largo (G.S.); (8) St. David's (A.C.C., 1868, and T. Drummond, 1871, R.B.G.); Inverkeithing (Dr. A. Dewar, 1845, R.B.G.); near Charlestown (J.H.B.).

Crepis Linn.

C. taraxacifolia Thuill. (*Hawk's Beard*)
Limestone districts. Very rare.
(8) St. David's (A.C.C., 1868 and 1890).

C. setosa Hall. fil. (*Barkhausia setosa* DC.)
Fields. Introduced with seed.
(7) Burntisland (A.C.C., 1868); (8) near N. Queensferry Toll-bar (Dr. Dewar, 1845).

C. capillaris Wallr. (*C. virens* L.) (*Smooth Hawk's Beard*)
Dry pastures, roadsides, wall-tops. Very common.

C. nicaeensis Balb.
(8) Ballast heaps, St. David's (W.E.E., 1902).

C. biennis L. (*Rough Hawk's Beard*)
In meadows by ditches and streams. Rare.
(8) Aberdour (A.C.C., 1883); St. David's (W.E.E., 1902).

C. mollis Aschers. (*C. succisaefolia* Tausch)
Woods. Very rare.
(8) Lethan's Glen (A.R.); near Inverkeithing (R.B.G.).

C. paludosa Moench (*Marsh Hawk's Beard*)
Moist woods and shady places. Not common.
(1) Balmerino (J.C.); (2) Kinkell Braes (J.H.W.); (3) Kenly Den (G.S.); (4) Kilconquhar (W.); (6) by River Ore (A.H.G.); (9) Lomond Hills (J.H.B.).

Hieracium Linn.

H. Pilosella L. (*Mouse-ear Hawkweed*)
Pastures and banks. Very common.

H. aurantiacum L. (*Orange Hawkweed*)
Woods and waste places. Uncommon.
(1) Balmerino (J.C.); (3) Crail (G.S.); (5) near Holl Reservoir (W.Y., 1924); (8) near Aberdour (A.R., 1832); Limekilns (J.H.B.); near Dunfermline (Dr. Dewar); (9) Kinross (W. Arnott).

H. amplexicaule L. (*Amplexicaul Hawkweed*)
Old walls. Naturalised introduction.
(9) Cleish Castle (A.R. and Fraser, 1835, R.B.G.).

H. anglicum Fr. (*H. cerinthoides* Backh. and *H. Lawsoni* Bab.)
(7) Between Pettycur and Burntisland (B. & S.); (8) near Dunfermline (B.); N. Queensferry (J.H.B.).

H. senescens Backh. (*Hoary Hawkweed*)
Grassy slopes and edges of streams. Rare.
(9) West Lomond Hill (B. & S.).

H. chrysanthum Backh.
(9) West Lomond Hill (B. & S).

H. nigrescens Willd.
Recorded by Professor Trail in A.S.N.H. (1906) without locality.

H. atratum Fr.
(9) Lomond Hills (J.H.B., 1855).

H. caledonicum F.J.H.
Recorded by Professor Trail in A.S.N.H. (1906) without locality.

H. sylvaticum Gouan (*H. murorum* L.)
Frequent.
(1), (2), (3), (4), (7), (8), (9).

H. vulgatum Fr.
(1) Balmerino (J.C.); (7) near Kirkcaldy (W.Y); Burntisland (J.H.B.); (8) N. Queensferry (Dr. Knapp, R.B.G.); near Fordel (Dr. Dewar); near Torryburn (J.H.B.).

var. **rosulatum** Syme
(7) Kirkcaldy (J.B.S., 1874, R.B.G.).

H. subramosum Lönnr.
Professor Trail (A.S.N.H., 1906, without locality).

H. Dewari Bosw.
(8) Banks of Black Devon.

H. gothicum Fr.
(9) Rumbling Bridge (certified by J.B.S., 1877).

H. rigidum Hartm.
(8) Banks of Black Devon (J.H.B., 1848).

H. prenanthoides Vill.
(8) Banks of Black Devon (J.H.B., 1852).

H. strictum Fr. (*H. denticulatum* Sm.)
(8) Lethan's Glen (A.R.); (9) Ochil Hills (B. & S.).
Professor Trail (A.S.N.H., 1906).

var. d. **amplidentatum** F. J. Hanbury
Professor Trail (A.S.N.H., 1906, without locality).

H. corymbosum Fr.
Between St. Andrews and Kinkell Ness (C. Bailey, Report of Record Club, 1881–82, p. 218).

H. sabaudum L.
(8) Lethan's Glen (A.R.).

var. b. **boreale** Fr.
(7) Burntisland (H. Cleghorn, 1838, R.B.G.); (8) banks of Black Devon (J.H.B., 1848); (9) Rumbling Bridge (B. & S.).

Hypochaeris Linn.

H. glabra L. (*Smooth Cat's Ear*)
Sandy places. Rare.
(1) Tents Muir (Dr. M. Wilson, 1934); (8) near Culross (Sonn.).

H. radicata L. (*Long-rooted Cat's Ear*)
Meadows, roadsides, etc. Common.

Leontodon Linn.

L. nudicaule Banks et Soland. (*L. hirtum* L., *Thrincia hirta* Roth)
Fields and waste places. Not common.
(3) East Neuk (W.); (8) N. Queensferry (B. & S.); St. David's (A.C.C.); Dunfermline (N.S.A.).
First record: Hooker (N. Queensferry, R. Maughan), as "*Apargia hirta*."

L. hispidum L. (*Rough Hawkbit*)
Meadows and pastures. Frequent.

L. autumnale L. (*Autumnal Hawkbit*)
Meadows and pastures. Common.

var. c. **sordidum** Bab.
(8) St. David's (A.C.C., 1867).

Taraxacum Hall.

T. officinale Weber (*Dandelion*)
Common everywhere.
First record: Sibbald, Inchkeith, as "Dentelyon."

T. erythrospermum Andrz.
Wet places. Very rare.
(4) Largo Links (G.S.); (7) Kirkcaldy Links (J.B.S.); Burntisland (1846, R.B.G.); near Pettycur (1845, R.B.G.).

var. b. **laevigatum** (DC.)
(4) Leven Links (M., & B.); (7) Burntisland (A.C.C.).

T. palustre DC.
Marshes. Frequent.
(1) Balmerino (J.C.); (2) Collessie and Cults parish (N.S.A.); (3) Parkmill, Kenly Den (G.S.); (7) near Burntisland (J.H.B.); (8) Inverkeithing (J.H.B.); Ferry Hills (A.R.); near Dunfermline (Dr. Dewar); (9) Cleish (A.R.); Lomonds (J.H.B.).

T. laetum Dahlst.
(7) Kirkcaldy (*fide* Druce in Trans. Bot. Soc. Edin., xxix, pt. 1, 1924, p. 5).

Lactuca Linn.

L. virosa L. (*Acrid Lettuce*)
In fields by roadsides, etc. Uncommon.
(1) Lindores Abbey (A.L.); Norman's Law (L. & S.); (2) St. Andrews (B.).

L. muralis Gaertn. (*Wall Lettuce*)
Old walls, etc. Introduced. Rare.
(3) Between Anstruther and Elie (J.H.B., 1864).

Sonchus Linn.

S. oleraceus L. (*Sow-thistle*)
Waste places. Very common.

S. asper Hill (*Sharp-fringed Sow-thistle*)
Waste places. Rare.
(1) Balmerino (J.C.); (4) near Colinsburgh (J.H.W., 1858); (7) Raith (B. & S.); near Kirkcaldy (A.H.G.); (8) St. David's Bay (W.E.E., 1902).

S. arvensis L. (*Corn Sow-thistle*)
Cornfields, roadsides, etc. Common.

Tragopogon Linn.

T. pratense L. (*Yellow Goat's Beard*)
Meadows and dry banks. Frequent.
(1), (2), (3), (4), (6), (7), (8).
First record: Greville, Burntisland, leg. Arnott.

T. minus Mill.
(4) Kilconquhar (B. & S.); (7) Kinghorn (B. & S.); Burntisland (J.H.B.).

T. porrifolium L.
Introduced.
(2) Cupar (J.H.B., 1867); (7) Burntisland (Miss Harvey); (9) Heathy moor between Hillside and Powmill.

CAMPANULACEAE.

Lobelia Linn.

L. Dortmanna L.
Lochs. Rare.
(1) Black Loch, Loch Dow, and Loch Darg (G.W.); (9) Cleish Loch and Loch Leven (A.R.).

Jasione Linn.

J. montana L. (*Sheep's Bit Scabious*)
Dry banks. Rare.
(3) Kilrenny and Largoward (W.); (4) Kincraig Braes (W.); Kilconquhar parish (N.S.A.); (8) St. David's (A.C.C., 1873).

Campanula Linn.

C. glomerata L. (*Clustered Bellflower*)
Dry pastures and margins of woods. Rare.
(1) Balmerino (J.C.); (3) East Neuk (W.) (Geo. Don); (7) Kirkcaldy (W.Y., 1886); Kinghorn (A.C.C., 1868); Pettycur (A.R.); Dysart (T. Thomson, 1836); (9) Cleish (A.R.).
The white form has been found (7) Kinghorn parish (N.S.A.).
First record: Hooker, Pettycur.

C. Trachelium L. (*Nettle-leaved Bellflower*)
Woods. Very rare.
(8) Donibristle (A.R., 1836).

C. latifolia L. (*Giant Bellflower*)
Moist shady woods. Uncommon.
(1) Black Loch (A.L.); Balmerino (J.C.); (3) Cambo and Kilrenny (W.); (4) Kilconquhar parish (N.S.A.); Largoward; (7) Raith (B. & S.); (9) Cleish parish (N.S.A.); Rumbling Bridge (J.H.B.); Kinross Woods (Hook.); Orwell (W.A.).

C. rapunculoides L. (*Creeping Bellflower*)
Woods, fields, gardens. Common. Naturalised.
First record: Hooker, at Balwearie Castle, near Kirkcaldy.

C. rotundifolia L. (*Harebell*) (*The Blue Bell of Scotland*)
Common everywhere.
The white form has been found (2) Cults parish (N.S.A.); Tents Muir (B.); (4) Leven Links (B.).

var. b. **lancifolia** Mert. & Koch
(7) Kinghorn (G.S.).

C. persicifolia L. (*Peach-leaved Bellflower*)
Introduced. Very rare.
(8) Near Limekilns (no collector, 1851, R.B G.).

C. Rapunculus L. (*Rampion Bellflower*)
Sandy places. Introduced. Very rare.
(7) Balwearie (B.); (8) Ferry Hills (R.S., 1896); Limekilns (J.H.B., 1851).

Legousia Durande (*Specularia* Heist.)

L. hybrida Delarbre
Waste places. Casual. Very rare.
(4) Largo Links (W.).

VACCINIACEAE.

Vaccinium Linn.

V. Vitis-Idaea L. (*Cowberry*)
Heaths and woods. Rare.

(3) East Neuk (W.); (4) Kilconquhar parish (N.S.A.); (8) Lethan's Glen (A.R.); (9) Cleish Hills (R.S., 1900); Lomond Hills (J.H.B., 1861); Orwell parish (N.S.A.).

V. Myrtillus L. (*Blaeberry*)
Woods, heathy places, hillsides. Common.

Oxycoccus Hill

O. quadripetala Gilib. (*O. palustris* Pers.) (*Cranberry*)

Bogs among sphagnum. Uncommon.

(1) Pitmenzie Bogs (A.L.); Forgan Bog (R.S.); (6) Loch Fitty (J.H.B.); Moss Morran (A.H.G.); (7) Begg Moss, near Kirkcaldy (W.Y.); near Balmuto (Miss Boswell); (8) Otterston Loch (K.N.S.); Knock Hill (Dr. Dewar); (9) Lomond Hills (B. & S.); Cleish Hills (A.R.) (W.E., 1900); Orwell (W.A.).

ERICACEAE.

Arctostaphylos Adans.

[**A. Uva-ursi** Spreng.

(9) "Said to have been found on Cleish Hills by an English botanist; since sought for in vain" (A.R.)].

Calluna Salisb.

C. vulgaris Hull. (*Heath* or *Ling*)

Hills and moors and by the seashore. Common.

The white form has been found (2) Tents Muir (B.).

Erica Linn.

E. Tetralix L. (*Cross-leaved Heath*)

Hills and moors. Common.

A white form has been found (2) Tents Muir (W.G.S., 1888); (9) Orwell parish (N.S.A.).

E. cinerea L. (*Fine-leaved Heath*)

Hills and moors. Common.

A white form has been recorded (2) Tents Muir and St. Andrews Links (B.).

Azalea Linn. (*Loiseleuria* Desv.)

A. procumbens L. (*Azalea*)

Hills. Very rare.

(2) East Lomond (L. & S.); (4) Balcarres Den (N.S.A.), a very doubtful record.

Pyrola Linn.

P. rotundifolia L. (*Round-leaved Wintergreen*)

Woods. Rare. Perhaps sometimes confused with *P. media* Sw.

(1) Near Newburgh (B.); near Butterwell and Weddersby Wood near Black Loch (A.L.); (2) Inchrye Woods (L. & S.); (7) near Kirkcaldy (1824); (8) near Dunfermline (W.L.L., 1848, and Dr. Dewar, 1845); Lethan's Dene (Dr. Dewar, 1848); banks of Black Devon (J.H.B., 1848); Culross (N.S.A.).

P. media Sw. (*Intermediate Wintergreen*)
Woods. Rare.
(1) Newburgh Hills (N.S.A.); (2) near St. Andrews (B.); (3) Kenly Den (B.); (4) Balcarres Den (W.); (6) Cardenden (B. & S.); (7) near Kirkcaldy (Sonn.); (8) Heath Wood near Dunfermline (W.L.L., 1848); Knock Hill (J.H.B., 1848); (9) Rumbling Bridge.

P. minor L. (*Lesser Wintergreen*)
Bushy localities. Rare.
(1) Balmerino (J.C.); Birkhill Woods (W.G.S.); (2) Collessie (N.S.A.); Cupar (J.H.B.); Drumcarro Craig (J.H.W.); Edensmuir (N.S.A.); (3) Sypsies Wood (G.S.); (6) near Lochgelly Moor (W.L.L.); (7) Balmuto (J.B.S.); (8) Hillend (K.N.S., 1836); N. Queensferry (B. & S.); banks of Black Devon (J.H.B.); (9) Benarty Hill (J.H.B.).

P. secunda L. (*Serrate Wintergreen*)
Shady fir-tree woods. Very rare.
(7) Burn of Duncarn, Darnaway Wood (Jas. Dickson, R.B.G.); (8) Dunfermline parish (N.S.A.); (9) Kinross (Walker-Arnott, 1837).

MONOTROPACEAE.

Monotropa Linn.

M. Hypopitys L. (*Yellow Bird's Nest*)
Woods. Needs verification.
(9) Cleish parish, A. Robertson. The only record.

PLUMBAGINACEAE.

Limonium Mill. (*Statice* L., p.p.).

L. vulgare Mill. (*Statice Limonium* L.)
Muddy salt marshes.
(4) Elie (J. W. Brown) (Sonn.).

Recorded by Professor Trail, without locality, but doubtful. Sibbald says, " Shores of Firth of Forth."

Statice Linn. (*Armeria* Willd.)

S. maritima Mill. (*Thrift, Seapink*)
Rocks and pastures on seacoast. Common.
First record: Sibbald, Inchkeith, as " seapink."

var. b. **planifolia** Syme
(3) Isle of May (H.C.W.); (4) Kincraig Point (C.G.); (8) Inchcolm (Woodford); and in A. Craig Christie's Herbarium (Sept. 1871) without locality.

var. c. **duriuscula** (Bab.)
(4) Kincraig Point (C.G.).

PRIMULACEAE.

Primula Linn.

P. vulgaris Huds. (*Primrose*)
Woods, banks, and pastures. Common.

P. veris L. (*Cowslip*)
Meadows, banks, and pastures. Frequent.

P. veris × vulgaris
Clayey woods and meadows. Probably introduced. Rare.
(1) Balmerino (J.C.); Wormit (W.G.S., 1884, " this must be hybrid "): (2) near Cupar (J. Knapp, 1835, R.B.G.); (3) Elie (B.): (4) Balcarres and Keil's Dens (B.); Dunbarnie Links and Kilconquhar (B.); (7) Balmuto (W.Y.); Kinghorn parish (N.S.A.); Burntisland (J.H.B.); Raith (A.H.G.); Auchtertool (B. & S.); (8) Ferry Hills (R.B.G.); Starleyburn, Carnock and Dunfermline parishes (N.S.A.); Aberdour (H.C.W.); Inverkeithing (J.H.B.); N. Queensferry (W.L.L.); Limekilns (1835, R.B.G.).
First record: Hooker, between Queensferry and Inverkeithing
This hybrid was confused with *P. elatior* Jacq. until comparatively recently, the above records being largely under that name. Some may refer to *P. vulgaris* Huds. var. *caulescens* Koch.

Lysimachia Linn.

L. vulgaris L. (*Great Yellow Loosestrife*)

Sides of rivers and pools. Rare. Doubtful native.

(3) Near Elie House to east in quarry holes (W.); (6) Lochgelly (B. & S.); (8) Otterston Loch (A. Gray); Donibristle (B. & S.); Dunfermline (R.B.G.).

L. Nummularia L. (*Creeping Loosestrife, Moneywort*)

Damp places. Very rare.

(4) Lahill, near Largo (C.G.); (5) River Leven, near Markinch (A.H.G., 1883); (8) Fordel (K.N.S., 1836); (9) Loch Leven (G.W.).

L. nemorum L. (*Yellow Pimpernel, Wood Loosestrife*)

Woods and damp shady places. Not common.

(1) Balmerino (J.C.); (2) Maspie Den; (4) Newburn (W.); Balcarres Den (N.S.A.); (8) Fordel (A.R., 1836); Morton Woods, Aberdour (W.L.L.); (9) Cleish (A.R.); Lomond Hills (W. Reid, 1837).

Trientalis Linn.

T. europaea L. (*Chickweed Wintergreen*)

Woods and heaths. Uncommon.

(1) Wood above Gathaway (A.L.); (2) West Lomond (D.); Black Hill, Falkland (C.G.); Drumcarro Craig (M.); Kinness Burn (J.H.W., " now extinct "); Cupar (J.H.B.); (3) Magus Moor (G.S.); (4) Norrie's Law, near Largo; (6) near Kennoway (B. & S.); Loch Fitty (J.H.B.); (7) near Kirkcaldy (W.Y.); Dysart (W. W. E., R.B.G.); (8) Knock Hill (J.H.B.); near Dunfermline (A.D., 1837); Carnock (J.H.B.); Lethan's Moor and Tulliallan (B. & S.); Saline Hills (W.L.L.); (9) Cleish (A.D., 1834, R.B.G.); Kinross (M.).

Glaux Linn.

G. maritima L. (*Black Saltwort*)

Seashores in gravelly places. Frequent.

(1) Ballinbreich (A.L.); Balmerino (R.S.); (2) Tents Muir (W.G.S.); near St. Andrews (W.); (3) Crail (G.S.); Kilrenny parish (N.S.A.); (4) Kincraig, Largo (W.Y.); (7) between Kirkcaldy and Kinghorn (W.Y.); Pettycur, Burntisland, Inchkeith (A.H.G.); (8) near Aberdour (1834, R.B.G.); Dalgety Bay, near Charlestown and St. David's (R.S.).

First record: Greville, North Queensferry.

Anagallis Linn.

A. arvensis L. (*Scarlet Pimpernel, Poor Man's Weather-glass*)
Cornfields and waste places. Not common.
(1) Balmerino (J.C.); Wormit (R.S.); Newport (W.G.S.); (2) Strathmiglo (B. & S.); Ladybank (J.H.B.); Tents Muir (R.S.); St. Andrews (J.H.W.); (3) Crail (G.S.); Anstruther (J.H.B.); Elie (C.G.); Ormiston (W.); (7) Kirkcaldy (W.Y.); Kinghorn (A.R.); Inchkeith (A.C.C.); Burntisland (B. & S.); (8) Inchcolm (A.C.C.); St. David's (W.L.L.); Inverkeithing, Ferry Hills, and Charlestown (J.H.B.).

A. foemina Mill. (*A. coerulea* Schreb.)
Waste places. Very rare.
(8) North of Inverkeithing (Dr. Dewar, one specimen) (A.R.), and recorded in Millar, same locality, July 1836.

A. tenella Murr. (*Bog Pimpernel*)
Wet boggy places. Rare.
(1) Forgan Bog (R.S.); (2) Tents Muir (J.H.B.); (3) Crail (G.S.); (4) Dunbarnie Links (W.Y.); (9) by Loch Leven (R.S.).

Centunculus Linn.

C. minimus L. (*Chaffweed*)
Moist shady places. Very rare.
(2) St. Andrews Links (R.B.G.); (8) near Dunfermline (1845, R.B.G.); (9) shores of Loch Leven (1864, R.B.G.).

Samolus Linn.

S. Valerandi L. (*Brookweed*)
Damp places. Native. Very rare.
(8) N. Queensferry (Barry); near Dunfermline and Limekilns (G. Don and Brodie in R.B.G.).
First record: Hooker, Limekilns.

OLEACEAE.

Fraxinus L.

F. excelsior L. (*Common Ash*)
Woods and hedges. Common and possibly native but generally planted.
(1) Balmerino (R.S.); Birkhill Woods (R.S.); (3) Crail

(G.S.); (7) park at Kirkcaldy (1854, R.B.G.); Bogie (A.H.G.); Burntisland (J.H.B.); (9) Kinross-shire (1836, R.B.G.).

Ligustrum Linn.

L. vulgare L. (*Privet*)

Hedges. Introduced. Common.

(4) Kilconquhar (J.H.B., 1859); (9) Rumbling Bridge (J.H.B., 1863).

APOCYNACEAE.

Vinca Linn.

V. major L. (*Greater Periwinkle*)

Woods and banks. Introduced.

(1) Balmerino (J.C.); (3) East Neuk (W.); (7) West Wemyss (W.W.E.); Raith (B. & S.); Burntisland (J.H.B., 1858).

V. minor L. (*Lesser Periwinkle*)

(2) Near Cupar (J.H.B.); (3) East Neuk (W.); (7) Raith (W.Y.).

GENTIANACEAE.

Centaurium Hill (*Erythraea* Renealm)

C. umbellatum Gilib. (*Centaury*)

Dry pastures. Rare.

(2) Tents Muir; (3) Pittenweem (B.); (4) Largo Links (W.); (7) by Tiel Burn and near Seafield Tower (W.Y.); Dunearn Hill (Greville); near Kinghorn (var. *album*); Burntisland (N.S.A.); (8) St. David's and Limekilns (R.S.).

First record: Sibbald, Wemyss and other places, as "*Gentiana Centaurium.*"

C. pulchellum Druce (*Dwarf-branched Centaury*)

Sandy places. Very rare. Records need verification.

(1) Newburgh (N.S.A.); (2) Tents Muir (B.).

Gentiana Linn.

G. Amarella L. (*Fellwort*)

Dry pastures. Frequent.

(2) St. Andrews Links (C.H.); (3) East Neuk (W.); (4)

Largo Links (C.G.); Kilconquhar (A.S., Aug. 1900); "Fife" (A. Bennet, Top. Bot., 1905).

First record: Sibbald, as "*Gentianella fugax minor.*"

G. campestris L. (*Field Gentian*)

Hilly pastures. Frequent.

(1) Near Newburgh; (2) Collessie parish and Tents Muir (N.S.A. and R.S., 1891); (3) Earlsferry (W.); (4) Dunbarnie Links, Largo (R.B.G.); (7) Pettycur (B. & S.); Burntisland (A.R.); (8) Ferry Hills (K.N.S., 1836); (9) Orwell parish (N.S.A.).

First record: Hooker, hills between Pettycur and Burntisland.

G. baltica Murb.

(4) Lundin Links (A.S., Sept. 1900, R.B.G.).

It has also been recorded from (1) Lindores Loch (L. & S.); Logie parish (N.S.A.); (2) Tents Muir (B.); (4) Kilconquhar parish (N.S.A.); and (9) Orwell parish (B.), but very doubtfully.

Menyanthes Linn.

M. trifoliata L. (*Buck-bean* or *Bog-bean*)

Marshy and boggy places. Frequent, chiefly in the northern part of the county on margins of lochs.

Nymphoides Hill (*Limnanthemum* S. G. Gmel.)

N. peltatum Rendle and Britten

Introduced.

(4) Kilconquhar Loch (B.).

POLEMONIACEAE.

Polemonium Linn.

P. coeruleum L. (*Jacob's Ladder*)

Banks, bushy places. Garden escape.

(2) Bankhead Moss (M.); Cupar (J.H.B.); (4) near Colinsburgh (C.G.); (7) Dysart (J.H.B., 1847); Pettycur (J.H.B.); (8) Donibristle and N. Queensferry (J.H.B.).

BORAGINACEAE.

Cynoglossum Linn.

C. officinale L. (*Hound's Tongue*)
Waste places. Frequent.
First record: Sibbald; no locality.

Asperugo Linn.

A. procumbens L. (*German Madwort*)
Waste and cultivated ground. Casual. Rare.
(8) Inchcolm (A.C.C., July 1881).

Symphytum Linn.

S. officinale L. (*Common Comfrey*)
Damp places. The var. *patens* frequent, the typical form rare.
(8) Fields near Limekilns (W.E.E., 1906, typical).

var. **patens** (Sibth.)
(4) Cockle Mill Burn (G.S., 1886); (8) Fordel and Pitreavie (A.R.).

S. tuberosum L. (*Tuberous Comfrey*)
River-banks and shady woods. Occasional.
(3) Crail (W.Y.); near Balcarres (C.G.); (6) by River Ore (W.Y.); (7) Raith (W.Y.); Dysart Woods (J.H.B.); Kinghorn Road (J.B.S.); (8) Otterston (A.R., 1837); Inverkeithing (N.S.A.); (9) Cleish (Hook.).

S. peregrinum (Ledeb.) (*S. asperrimum* Bab.)
Naturalised.
(4) Near Kilconquhar (Jas. Fraser. 1913); also recorded in Trans Bot. Soc. Edin., vol. xxvi, p 235, from (2) Cupar; (7) Dysart Woods and Kirkcaldy; (8) Charlestown and Torryburn.

S. orientale L.
(7) Raith (A.H.G., 1883, R.B.G.); Dysart; and (8) Aberdour (M.).

S. tauricum Bab.
(7) Dysart Woods (J.H.B., May 1852), escape from garden.

Borago Linn.

B. officinalis L. (*Borage*)
Waste ground. Introduced. A garden escape.

(2) Near Falkland (C.G.); St. Andrews (J.H.B.); (3) Caiplie (W.); (7) Kinghorn (A.C.C. and B. & S.); Burntisland (N.S.A. and J.H.B., 1850); (8) St. David's (A.H.G.).

First record: Sibbald, Inchcolm (8).

Anchusa Linn.

A. officinalis L. (*Common Alkanet*)

Waste places. Casual. Very rare.

(8) St. David's (A.C.C., June 1876).

A. sempervirens L.

Waste places near ruins. Not common.

(2) Near St. Andrews (B.); (3) Crail, by roadside towards Balcomie (W.Y.); (6) between Crossgates and Kelty; (7) Macduff Castle (A.H.G.); Wemyss, Dysart, and Raith (J.H.B.); Burntisland (N.S.A.); Cullaloe (J.B.S.); (8) Inchcolm (A.C.C.); Culross (A.R.); Pitreavie (Dr. Dewar); Inverkeithing (A.R.); (9) Kinross-shire (Maughan).

First record: Hooker, near Crossgates.

Lycopsis Linn.

L. arvensis L. (*Bugloss*)

Fields and hedges. Very common.

Pulmonaria Linn.

P. officinalis L. (*Lungwort*)

Woods and thickets. Introduced.

(4) Kilconquhar Loch (C.G.); (7) Raith (A.H.G.); Balmuto (A.C.C.); Burntisland (J.H.B., 1861).

Mertensia Roth

M. maritima Gray (*Oyster Plant, Smooth Gromwell*)

Seacoast among sand and stones. Very rare.

(2) Near St. Andrews (Lightfoot and Hooker); (3) Fifeness (G.S., 1863); east of Anstruther (R. Maughan, 1821); near Elie (J. Sadler, 1863, and J.H.B., 1865); Earlsferry (J. Knapp, 1855); (4) near Kincraig Point (W.Y., 1912); (7) near Seafield Tower (Greville); (8) near N. Queensferry (W. Middleton, 1821).

One plant was seen in 1912 near Kincraig Point, but when the spot was revisited in 1920 the site was covered to a depth of several feet with sea-ware. So it is very doubtful if a

single plant could now be found anywhere on the Fifeshire coast, as it has been extinct for many years in the other localities mentioned.

Myosotis Linn.

M. caespitosa Schultz (*Tufted Water Scorpion Grass*)
Watery places by ponds and ditches. Frequent.
(1) Lindores Loch (A.L.); (3) Crail (G.S.); (4) Kilconquhar Loch (W.); (6) Lochgelly, Hillhead Loch (A.R.); (8) Ferry Loch, Inverkeithing (A.R., 1836); Dunfermline (B. & S.); (9) Loch Leven (B. & S.); Lomond Hills (W.Y.).

M. scorpioides L. (*M. palustris* Hill) (*Forget-me-not*)
Wet places. Common.

var. **strigulosa** (Reichb.)
(3) Crail (G.S.).

M. repens G. & D. Don (*Creeping Scorpion Grass*)
Boggy places. Rare.
(1) Forgan Bog (R.S.); Calais (R.S.); (2) Tents Muir (R.S.); West Lomond Hill (J.H.B., 1865) (W.Y., 1916); (3) East Neuk (W.); (9) Orwell parish (N.S.A.).

M. sylvatica Hoffm. (*Wood Scorpion Grass*)
Dry shady places. Very rare.
(1) Balmerino (J.C.); (3) Cambo (G.S.); (7) Kirkcaldy (W.Y.); (8) Fordel, Donibristle, and Inverkeithing (A.R.); (9) Orwell parish (N.S.A.).

M. arvensis Hill (*Field Scorpion Grass*)
Cultivated ground and hedge-banks. Common.

M. collina Hoffm. (*Early Field Scorpion Grass*)
Dry banks. Common.

M. versicolor Sm. (*Yellow and Blue Scorpion Grass*)
Dry banks and meadows. Common.

Lithospermum Linn.

L. purpureo-caeruleum L.
Introduced.
(8) St. David's (A.C.C., June 1880).

L. officinale L. (*Gromwell*)
Dry waste places, roadsides. Rare.
(3) Near Crail (W.Y.); (8) Culross (Drs. Dewar & Currer, 1834); (R.B.G., Walter Scott, July 1836; no locality).

L. arvense L. (*Corn Gromwell*)
Dry grounds. Frequent.
Spread by agriculture if not introduced.

Echium Linn.

E. vulgare L. (*Viper's Bugloss*)
Dry banks, sandy fields, and rocky places. Plentiful where it occurs.
First record: Sibbald, Inchcolm (albino form).

CONVOLVULACEAE.

Calystegia Br.

C. sepium L. (*Great Hooded Bindweed*)
Woods and hedges. Frequent. Usually an escape.

C. Soldanella Br. (*Seaside Bindweed*)
(1) Near Ballinbreich (A.L., 1876). Needs verification.

Convolvulus Linn.

C. arvensis L. (*Small Bindweed*)
Cornfields, dry banks, roadsides, etc. Frequent.
First record: Greville, "Kirkcaldy, abundant near the seashore."

Cuscuta Linn.

C. Epithymum Murr. (*Lesser Dodder*)
(2) Lucklaw Hill, on *Erica* (B.); (4) Largo Law, on Trefoil (B., & W.). These are very doubtful records.

C. Trifolii Bab. (*Clover Dodder*)
(7) Between Kirkcaldy and Seafield in clover fields (J.B.S., Aug. 1869, R.B.G.).

SOLANACEAE.

Solanum Linn.

S. Dulcamara L. (*Bitter Sweet, Woody Nightshade*)
Moist hedges and thickets. Not common.
(2) Auchtermuchty (M.); Tents Muir (N.S.A.); banks of Eden (W.G.S.); Collessie parish (N.S.A.); (4) Charleton

Woods (W.); (7) by Tiel Burn (W.Y.); Kinghorn (B. & S.); Burntisland (W.W.E., 1846); Raith (A.H.G.); (8) Starleyburn (Greville); Dalgety (K.N.S., 1836); Culross (A.R.); Pitreavie (R.S.).

First record: Sibbald, without locality.

S. nigrum L. (*Black Nightshade*)

Woods and waste ground. Not common.

(1) Tayport and near Ferryport (B.); (2) St. Andrews (J.H.B., 1861, and C.H.); (7) Burntisland (J.B.S., 1871, R.B.G.); (8) St. David's (A.R. & A.H.G., 1882); Inverkeithing and Charlestown (A.C.C.).

First record: Sibbald, without locality.

var. **miniatum** (Bernh.)

(8) St. David's (A.R.).

Lycium Linn.

L. chinense Mill. (*L. barbarum* L.)

Waste places. Naturalised. Very rare.

(3) Elie (J.H.B., 1872) (A.S., 1899) (Fraser); (4) Kincraig (W.Y., 1920); (7) Burntisland (J.H.B., 1869); (8) N. Queensferry (A.C.C., 1869); Limekilns (J.H.B., 1866).

Atropa Linn.

A. Belladonna L. (*Deadly Nightshade*)

Waste places. Introduced. Rare.

(3) East Neuk (W.); (7) Burntisland (J.H.B., 1854); (8) Donibristle (J.H.B., 1847) (Brodie n.d.); Inchcolm (R. Maughan, 1810); west of Aberdour (A.C.C., 1865); Charlestown (A.C.C., 1866, and J.H.B., 1850); near Crombie Point (R.S., 1896); Limekilns (Grev.).

First record: Sibbald, Inchcolm, as "*Solanum victum belladonna.*"

Hyoscyamus Linn.

H. niger L. (*Henbane*)

Waste places. Sporadic. Not common.

(1) Lindores Abbey (A.L.); (3) north of Fife Ness (W.Y.); St. Monans (C.G.); (4) Kincraig (J. B. Duncan); (7) Wemyss Castle (W.E., 1868); Kirkcaldy (W.Y.); (8) Starleyburn; (8) Culross (Lumley, 1906).

SCROPHULARIACEAE.

Verbascum Linn.

V. Thapsus L. (*Great Mullein*)

(1) Lindores Abbey and Ballinbreich (A.L., 1873); (3) Carphin (G.S.); East Neuk (W.); (7) Macduff Castle (A.H.G.); West Wemyss (R.B.G., 1835); Dysart (J.H.B., 1850); (8) Inchcolm (R.B.G., 1828) (A.C.C., 1865); near Torryburn (J.H.B., 1853); (9) Kinross (B. & S.).

First record: Lightfoot, "between E. and W. Wemyss."

V. Lychnitis L. (*White Mullein*)

Waste places. Rare.

(1) Den Mill, Newburgh, on walls of old garden (J.H.B., 1864); Lindores Abbey (A.L.); (3) East Neuk (W.).

V. nigrum L. (*Dark Mullein*)

Waysides. Introduced. Very rare.

(3) Near Elie (J. Knapp, 1843, R.B.G.); (8) Dunfermline (N.S.A.).

V. virgatum Stokes

Gravelly banks. Rare.

(1) Logie (J. Dewar, 1835); (8) near St. David's (Dr. Dewar, 1879); Otterston (R.B.G.).

Linaria Hill

L. Cymbalaria Mill. (*Ivy-leaved Toadflax*)

Old walls. Common.

L. purpurea Mill.

Old walls. Naturalised.

(7) Burntisland (A.C.C., 1884).

L. repens Mill. (*Creeping Pale Blue Toadflax*)

Banks and rocks near the sea. Very rare.

(8) Inverkeithing (A.R.).

L. vulgaris Mill. (*Yellow Toadflax*)

Hedges, rocks, and banks. Frequent.

L. minor Desf. (*L. viscida* Moench)

Sandy and gravelly fields. Very rare.

(3) Crail (G.S.), "casual"; (8) Charlestown (A.C.C., 1871); (9) Kinross-shire (F. B. White), naturalised on gravel walks.

Antirrhinum Linn.

A. majus L. (*Great Snapdragon*)
Old walls and cliffs. Rare.
(7) Burntisland (B. & S.); (8) Aberdour Castle (J.H.B., 1855) (A.C.C., 1865); Aberdour (W.E.E., 1904); Queensferry (R.B.G., ex herb. Dunsmure).

A. Orontium L.
Alien.
Dry, sandy, and gravelly fields.
(8) Charlestown (P. B. Gibb, n.d., R.B.G.).

Scrophularia Linn.

S. aquatica L. (*Water Figwort*)
Wet places. Not common.
(1) Balmerino (J.C.); (2) Tents Muir and St. Andrews (J.H.B.); Kinness Burn (J.H.W.); (3) Kenly Den (B.); (4) Kilconquhar Loch (W.); Lower Largo (R.B.G., no collector, 1843); (7) Burntisland (B. & S.); (8) Kincardine (J.H.B.).

S. alata Gilib. (*S. umbrosa* Dum.)
Wet places. Very rare.
(2) Leuchars (C. Bailey); also recorded by Prof. Trail in A.S.N.H. without locality.

S. nodosa L. (*Knotted Figwort*)
Woods and moist places. Very common.

S. vernalis L. (*Yellow Figwort*)
Waste places. Frequent.

Mimulus Linn.

M. Langsdorffii Donn (*M. luteus* L.)
Boggy places. American plant. Naturalised.
(1) River Tay (A.L.); Newburgh (M.); (2) Tents Muir (J.H.B.); River Eden (M.); (3) Kenly Burn (G.S.); (4) Kilconquhar Loch (W.); (7) Raith (J.H.B.); Tiel Burn, at Balwearie Mill (W.Y.); (8) N. Queensferry (B. & S.); (9) Loch Leven (R.S.).

M. moschatus (*Scented Musk*)
Damp places. Very rare. Probably an escape.
(7) By Raith Lake (A.H.G., 1882, R.B.G.).

Digitalis Linn.

D. purpurea L. (*Foxglove*)
Dry banks and woods. Common.

Veronica Linn.

V. hederaefolia L. (*Ivy-leaved Speedwell*)
Fields and banks. Common.
(1), (3), (7), (8).

V. didyma Ten. (*V. polita* Fr.)
Fields and waste places. Not common.
(3) Near Elie (J. W. Brown, 1862, R.B.G.); (7) Dysart Woods and near Kinghorn (J.H.B., 1862); Balmuto and Burntisland (B. & S.); (8) Inverkeithing (K.N.S., 1836); Dunfermline (N.S.A.).

V. agrestis L. (*Green Field Speedwell*)
Fields and waste places. Common.
First record: R.B.G., no collector, 1834.

V. Tournefortii C. Gmel. (*V. Buxbaumii* Ten.)
Fields. Rare.
(2) St. Andrews (J.H.B.); (3) Crail (G.S.); (7) Burntisland (J.H.B.); (8) Inverkeithing (Dr. Dewar, 1836); St. David's and Rosyth Castle (B. & S.); Dunfermline (Dr. Dewar).

V. arvensis L. (*Wall Speedwell*)
Dry fields, walls. Common.

V. serpyllifolia L. (*Thyme-leaved Speedwell*)
In pastures and by waysides. Common.
var. **tenella** All. (*V. humifusa* Dicks.)
(7) Balbarton, near Kirkcaldy (A.H.G., 1883, R.B.G.).

V. officinalis L. (*Common Speedwell*)
Dry pastures, woods. Very common.
var. **hirsuta** (Hopkirk)
(2) Melville Woods (L. & S.).

V. Chamaedrys L. (*Germander Speedwell*)
Common everywhere.
First record: Sibbald, Inchkeith (7), as "Wild Germander."

V. montana L. (*Mountain Speedwell*)
Moist woods and shady places. Rare.

(1) Birkhill Woods (R.S.); (4) Balcarres Den (W.); (7) near Kirkcaldy (A.H.G., R.B.G.); (9) Cleish Hills (A.R. and R.S., 1900).

V. scutellata L. (*Marsh Speedwell*)
Boggy places. Frequent.
First record: Greville, "Marshes, near N. Queensferry, Neill."

V. Anagallis-aquatica L. (*Water Speedwell*)
Ditches and watery places. Frequent.
First record: Hooker, Burntisland (7).

V. Beccabunga L. (*Brooklime*)
Ditches, streams, and ponds. Very common.

Euphrasia Linn.

E. Rostkoviana Hayne (*E. officinalis* L.) (*Eye-bright*)
Pastures, heaths, and roadsides. Very common.

E. brevipila Burnat et Gremli
Locality not given, R. Smith (A.S.N.H., 1902).
Note.—This genus requires investigation.

Bartsia Linn.

B. Odontites Huds. (*Red Eyebright*)
Cornfields, pastures, waysides. Very common.
var. **serotina** (Dum.)
(7) Balmuto (J.B.S., 1874); Cullaloe (J.B.S., 1869).

B. viscosa L. (*Viscid Bartsia*)
Fields. Very rare. Requires verification.
(8) N. Queensferry (Sonn.).

[**B. alpina** L. (*Alpine Bartsia*)
Recorded by Wood from "fields near Colinsburgh," but obviously an error for *B. Odontites.*]

Pedicularis Linn.

P. palustris L. (*Marsh Lousewort*)
Wet and marshy pastures. Common.
A white form has been recorded (2) Tents Muir (B.).

P. sylvatica L. (*Pasture Lousewort*)
Moist heathy pastures. Not common.
(1) Balmerino (J.C.); (2) Kinkell (G.S.); (3) East Neuk

(W.); (4) Largoward (C.G.); (7) Balmuto (W.Y.); Cluny (A.H.G.); (8) Dalgety (A.D., 1836); Dunfermline (B. & S.).

Rhinanthus Linn.

R. major Ehrh. (*Large Yellow Rattle*)

Meadows and damp fields. Rare.

(1) Near Newport (J. M'Nab, 1837, R.B.G.); (2) Tents Muir and between Forret and Leuchars (J.H.B.); Edenside (C.H.); St. Andrews (B.); (4) Kilconquhar (G.S.); Leven Links (B. & S.); (9) near Kinross.

var. **apterus** Fr.

Alien.

Recorded by Prof. Trail in 1904, without locality.

R. Crista-galli L. (*Yellow Rattle*)

Meadows and roadsides. Very common.

Melampyrum Linn.

M. pratense L. (*Yellow Cow-wheat*)

Woods and thickets. Not common.

(1) Balmerino (J.C.); (2) Black Hill, Falkland (C.G.); (8) Lethan's Glen (A.R.).

OROBANCHACEAE.

Orobanche Linn.

[**O. major** L. (*Greater Broom-rape*)

(8) Cliff below St. David's (B. & S.). Probably an error for *O. rubra* Sm.]

O. rubra Sm. (*Red Broom-rape*)

Banks, parasitic on roots of *Thymus Serpyllum.*

(4) Kincraig Braes (W.); Kilconquhar beach (N.S.A.); (7) between Kirkcaldy and Kinghorn (W.W.E., 1836–40) (J.H.B.); near Pettycur (K.N.S., 1837); Burntisland (A.C.C.); (8) St. David's (J. Maughan, 1820, R.B.G.).

First record: Sibbald, St. David's.

O. minor Sm. (*Lesser Broom-rape*)

(7) North Glassmount, in clover fields (J.B.S., Sept. 1874).

Lathraea Linn.

L. Squamaria L. (*Toothwort*)

Woods and thickets. Parasitic upon Hazels, etc.

(2) Melville Castle Woods (J. Henderson, 1842, R.B.G.).

LENTIBULARIACEAE.

Utricularia Linn.

U. vulgaris L. (*Greater Bladderwort*)
Ditches, lochs, and ponds. Rare.
(1) Black Loch (G.W.); Forgan Bog (R.S.); (9) Loch Leven (B. & S.).

U. minor L. (*Lesser Bladderwort*)
(1) Forgan Bog (R.S.); (7) Kinghorn (M.); (9) Lomond Hills (B. & S.).

U. intermedia Hayne
(1) Forgan Bog (R.S., 1892); bog ½ mile east of Forgan Manse (R.S., 1894), where a form occurs with bladders on special branches without leaves.

Pinguicula Linn.

P. vulgaris L. (*Butterwort*)
Boggy places and damp heaths. Frequent.

VERBENACEAE.

Verbena Linn.

V. officinalis L. (*Vervain*)
Waste ground. Very rare.
(2) St. Andrews (R.B.G., 1859); Craighall ruins, near Ceres (B.). extinct: (8) roadsides west from Queensferry (Brodie, R.B.G.); near Inverkeithing (R.B.G., 1829); Charlestown (A.C.C., Sept. 1871); St. David's (B. & S.).
First record: Lightfoot, "Without the gates, Inverkeithing, Parsons."

LABIATAE.

Mentha Linn.

M. rotundifolia Huds. (*Round-leaved Mint*)
Needs verification, probably confused with *M. longifolia* Huds.
(1) Balmerino (J.C.); (9) Rumbling Bridge (J.H.B., 1863).

M. longifolia Huds. (*M. silvestris* Lej.)
Waste and damp places. Introduced.
(3) East Neuk (W.); (9) Rumbling Bridge (J.H.B., 1863).

M. spicata L. (*M. viridis* L.)
Waste and damp places. Introduced.
(2) Between Collessie and Kinloch (N.S.A., "undoubted native"); Ladybank (J.H.B.); Ceres (A.R.); (8) Aberdour (A.C.C., 1865); Otterston Loch (A. Gray, R.B.G.); Inverkeithing and Carnock (A.R.); (9) Crook of Devon and near Milnathort (A.R.).

M. piperita L. (*Peppermint*)
Wet places. Rare.
(1) Balmerino (J.C.); (2) Ceres (A.R.); (4) ditch between Ceres and Largo (B.); (8) Inverkeithing (A.D., 1836, R.B.G.); N. Queensferry and Dunfermline (A.R.); (9) Orwell parish (N.S.A.).

var. **officinalis** (Hull)
(4) Lundin Links (A.S., 1900, R.B.G.).

M. aquatica L. (*Water Capitate Mint*)
Marshes and sides of streams. Common.

var. **hirsuta** (Huds.)
(4) Kilconquhar Loch (C.G.); (7) Kirkcaldy (W.Y.); (9) Orwell parish (N.S.A.); Kinross (B.).

var. **subglabra** Baker
(4) Kilconquhar Links (A.S., Aug. 1900, R.B.G.).

× **arvensis** (*sativa* Linn.)
(1) Lindores Loch (G.W.); (2) Tents Muir (M.); (3) Crail (G.S.); (4) Dunbarnie Links (M.); (8) N. Queensferry (B. & S.); (9) near Cleish (A.D.).

var. **paludosa** (Sole)
(4) Kilconquhar (G.S.).

× **longifolia** (*pubescens* Willd.)
Recorded by Professor Trail, without locality.

var. **palustris** (Sole)
(7) Kirkcaldy (W.Y.).

M. rubra Sm.
Needs verification.
(4) Largo Links (J. Knapp, 1837, R.B.G.); (9) Cleish (Dr. Dewar, 1845, R.B.G.).

M. gentilis Linn.
Needs verification.
(8) Near Dunfermline (Dr. Dewar, 1834).

M. arvensis L. (*Corn-mint*)
Cornfields. Common.

M. Pulegium L.
Needs verification.
Introduced. Recorded by Professor Trail, without locality.

Lycopus Linn.

L. europaeus L. (*Gipsy-wort*)
Ditches and river-banks. Rare.
(1) Near Newburgh (L. & S.); Lindores Loch (G.W.); (2) Tents Muir (M.); River Eden (W.); (7) West Grange (K.N.S., 1835, and Dr. Dewar, R.B.G.); near Den Craig (A.R. & Dr. D., 1835).
First record: Hooker, Lindores.

Origanum Linn.

O. vulgare L. (*Marjoram*)
Dry hills and waste places. Frequent.
First record: Greville, "near Burntisland by the shore, Neill."

var. **megastachyum** (Link)
(8) Starleyburn (A.R.).

Thymus Linn.

T. Serpyllum L. (*Wild Thyme*)
Hills, banks, and heaths. Common.
First record: Sibbald, as "Wild time."

T. Chamaedrys Fr.
(1) Balmerino (J.C.); (3) East Neuk (W.); (4) Largo Links (G.S.).
In view of recent research, all records for this genus need careful revision.

Clinopodium Linn.

C. vulgare L. (*Wild Basil*)
Dry waste and stony places. Not common.
(1) Balmerino (J.C.); near Wormit (W.G.S.); (3) Kenly Den (G.S.); (4) Balcarres Den (W.); (7) Raith (J.H.B.);

Balwearie (A.H.G.); Kirkcaldy (W.Y.); Burntisland and Cullaloe hills (A.R.); (8) Aberdour (A.C.C.); near Dunfermline (A.R.); (9) Rumbling Bridge (J.H.B.).

First record: Sibbald, as "*Clinopodium majus.*"

Calamintha Lam.

C. Acinos Clairv. (*C. arvensis* Lam.) (*Basil Thyme*)

Dry banks and gravelly places. Rare.

(2) St. Andrews (M.); (4) Largo Links (G.S.), and with white flowers (J. Knapp, 1843, R.B.G.); Colinsburgh Road (W.); (8) N. Queensferry (B. & S.); (9) Orwell parish (N.S.A.).

Salvia Linn.

S. Verbenaca L. (*Wild English Clary, Sage*)

Dry banks. Rare.

(2) St. Andrews (B.); Kinness Burn (J.H.W., "extinct"); (3) Ardross (W.); (7) East Wemyss (F.M.W., 1877, R.B.G.); Dysart (L. & S.); Ravenscraig (J.H.B.); Kirkcaldy (Lightfoot, extinct); Seafield (A.H.G.); Pettycur (Grev.); Burntisland Harbour (N.S.A.), still there in August 1935 (W.Y.).

First record: Lightfoot, "Dysart and Kirkcaldy."

S. verticillata L.

Alien.

(3) St. Monans (Trans. Bot. Soc. Edin., Vol. xxvi, p. 405); (7) Burntisland (Fraser, 1913); (8) west of N. Queensferry (Brodie n d., R.B.G.).

Nepeta Linn.

N. Cataria L. (*Cat Mint*)

(8) Near Culross (Sonn.).

N. hederacea Trev. (*N. Glechoma* Benth.) (*Ground Ivy*)

Hedges, banks, and waste places. Common.

First record: Sibbald, Inchkeith, as "Ground-ivy."

Scutellaria Linn.

S. galericulata L. (*Skull-cap*)

By banks of streams and marshy places. Not common.

(1) Lindores Burn (A.L., "once"); Balmerino (J.C.); (2) near Cupar (B. & S.); (3) East Neuk (W.); (7) Burntisland Reservoir (G.W.); Dunearn Hill (A.C.C.); (8) marshy ground on shore west of Aberdour (M.); (9) Cleish (N.S.A.).

Prunella Linn.

P. vulgaris L. (*Self-heal*)

Roadsides and pastures. Common.

First record: Sibbald, (8) Inchcolm, white variety, which was still there in 1881 as recorded by A. Craig Christie.

Marrubium Linn.

M. vulgare L. (*White Horehound*)

Roadsides and waste places. Rare. Casual.

(2) St. Andrews (J.H.B., 1858); (3) East Neuk (W.); (7) Inchkeith (W.W.E. 1847, R.B.G.); (8) Inchcolm (J.H.B.); N. Queensferry (Brodie, n.d., R.B.G.); Inverkeithing (A.R.).

First record: Lightfoot, "about Burntisland."

Stachys Linn.

S. officinalis Trev. (*Betonica officinalis* L.) (*Wood Betony*)

Woods and thickets. Rare.

(1) West of Newburgh (C.H.); (2) Strathmiglo (B. & S.); Auchtermuchty (M.); (6) by River Ore (A.H.G.) (W.W.E., 1844, R.B.G.); (8) Broomhall (C.H.); North Queensferry (J. Duncan, 1831).

S. palustris L. (*Marsh Woundwort*)

Banks of streams and ditches. Common.

× sylvatica (*ambigua* Sm.)

(8) Near N. Queensferry (1838) and near Dunfermline (1845) (Dr Dewar, R.B.G.).

S. sylvatica L. (*Hedge Woundwort*)

Woods and shady places. Very common.

First record: Greville, North Queensferry.

S. arvensis L. (*Corn Woundwort*)

Dry cornfields. Frequent

Galeopsis Linn.

G. Ladanum L. (*G. intermedia* Vill.) (*Ironwort*)

Gravelly and sandy places. Frequent.

G. speciosa Mill. (*G. versicolor* Curt.) (*Hemp Nettle*)

Cultivated fields. Common.

G. Tetrahit L. (*Common Hemp Nettle*)

Cornfields and waste places. Common.

Leonurus Linn.

L. Cardiaca L. (*Common Motherwort*)
Waste places. Introduced. Rare.
(8) St. David's (J.H.B., 1853); Inverkeithing (A.C.C., 1865); N. Queensferry (B. & S.).

Lamium Linn.

L. amplexicaule L. (*Henbit Dead Nettle*)
Fields and waste places. Common.

L. molucellifolium Fr. (*L. intermedium* Fr.) (*Intermediate Dead Nettle*)
Waste places. Frequent.

L. hybridum Vill. (*L. incisum* Willd.) (*Cut-leaved Dead Nettle*)
Cultivated and waste ground.
(4) Kincraig (W.); (7) Seafield Tower (R.B.G., 1854); Burntisland (J.H.B., 1856); (8) Inverkeithing (1836); N. Queensferry (J.H.B.).

L. purpureum L. (*Red Dead Nettle*)
Common everywhere.

L. maculatum L. (*Spotted Dead Nettle*)
Waste places. Rare.
(1) Balmerino (J.C.); (4) Kilconquhar (B. & S.); (8) Carnock (Dr. Dewar & A.R.); Carneil (K.N.S., 1835); near Dunfermline (Dr. Knapp); Charlestown (B. & S.); Torryburn (A.D., 1834, R.B.G.); St. David's (J.H.B.).

L. album L. (*White Dead Nettle*)
Roadsides and railway banks. Common.

L. Galeobdolon Crantz (*Yellow Weasel-snout*)
Damp woods, hedges. Rare. Introduced.
(6) Lochore (J.H.B., 1860); (7) Kinghorn (F.C.C., 1905); East of Burntisland (W.E.E., 1903); (8) near Dunfermline (1829, R.B.G.); (9) Lomond Hills (R.B.G., 1861).

Ballota Linn.

B. nigra L. (*Black Horehound*)
Waste places. Rare.
(3) East Neuk (W.); (7) near Dysart (R.B.G., 1854); Burntisland (lanes near church) (N.S.A.) (J.H.B., 1847); (8) Inverkeithing, St. David's, and N. Queensferry (A.R.); Culross (N.S.A.).

Teucrium Linn.

[**T. Scordium** L. (*Water Germander*)
Probably an error for *T. Scorodonia* L.
(4) Balcarres Den (W.).]

T. Scorodonia L. (*Wood Sage*)
Woods, banks, and waste places. Very common.

Ajuga Linn.

A. reptans L. (*Common Bugle*)
Moist pastures and woods. Common.

PLANTAGINACEAE.

Plantago Linn.

P. major L. (*Greater Plantain*)
Pastures and roadsides. Very common.
var. **intermedia** (Gilib.)
(2) Near St. Andrews (C. Bailey).

P. media L. (*Hoary Plantain*)
Meadows and pastures. Not common.
(2) Falkland (B. & S.); Leuchars (M.); St. Andrews (J.H.W.); (5) Leven (W.); (7) Kirkcaldy (B. & S.); (8) Pitreavie (R.S.); Charlestown (R.B.G., 1851); Hillside (A.D., 1839).

P. lanceolata L. (*Ribwort Plantain*)
Roadsides and meadows. Very common.
var. **sphaerostachya** Röhl.
(8) N. Queensferry (K.N.S., 1845).

P. maritima L. (*Sea Plantain*)
Marshes and waste ground on seacoast. Common.
First record: Greville, between Kirkcaldy and Pettycur.
A viviparous form has been found, J. Knapp (without locality 1843, R.B.G.).

P. Coronopus L. (*Buck's Horn Plantain*)
Gravelly coasts. Common.

Littorella Bergius

L. uniflora Aschers. (*L. lacustris* Linn.) (*Plantain Shoreweed*)
In watery, sandy places. Rare.
(1) Lindores Loch (G.W.); Black Loch and Lochmill Loch

(A.L.); (2) near Falkland; Collessie; Tents Muir; St. Andrews Links (C.H.); Cupar (J.H.B.); (6) Lochs Fitty and Gelly (A.R.); (7) Kinghorn Loch (R.B.G.); between Pettycur and Burntisland (J.H.B., 1847); Dunearn Hill; (8) Otterston Loch (1836); Black Loch (G.W.); (9) Cleish Loch (A.R.); Lomond Hills (B. & S.); Orwell (W.A.).

First record: Greville, " marsh on Dunearn Hill, Neill."

ILLECEBRACEAE.

Corrigiola Linn.

C. littoralis L. (*Strapwort*)

Sandy shores. Adventive.

(8) Charlestown (A.C.C., Sept. 1870); " Mr. Curror " (M.).

Scleranthus Linn.

S. annuus L. (*Annual Knawel*)

Sandy and gravelly places. Common.

CHENOPODIACEAE.

Chenopodium Linn.

Records of the less common species need revision.

C. polyspermum L.

Very rare.

(1) Balmerino (J.C.).

C. Vulvaria (*C. olidum* Curt.) (*Stinking Goosefoot*)

Waste places. Frequent.

C. album L.

Waste places. Common.

var. **viride** (L.)

(3) Isle of May (G.S.); (8) St. David's (A.C.C.).

C. murale L. (*Sowbane*)

Rare.

(8) Charlestown (K.N.S., Sept. 1844).

C. hybridum L. (*Maple-leaved Goosefoot*)

Waste places and fields. Introduced. Rare.

(8) Ferry Hills and Inverkeithing (A.R.).

C. urbicum L. (*Upright Goosefoot*)
Waste places. Rare.
(2) St. Andrews (D.-H.); (3) East Neuk (W.); (8) St. David's (A.C.C.); Inverkeithing (A.R.); N. Queensferry (Sonn.).

C. rubrum L. (*Red Goosefoot*)
Waste places, salt marshes. Rare.
(3) East Neuk (W.); (7) Burntisland Docks (F.M.W., 1878, R.B.G.); (8) St. David's (A.R., 1836); near N. Queensferry (R.B.G., 1837); Charlestown (B. & S.); Dunfermline (N.S.A.).

var. **pseudo-botryoides** Wats.
(1) Lindores Loch (B.W. in S.N., 1879); (3) East Neuk (W.); (7) Kinghorn Loch (J.B.S., Sept. 1870, Oct. 1871, R.B.G.).

C. botryodes Sm.
Needs verification. Probably *C. rubrum* var. *pseudo-botryoides* Wats.
(8) St. David's (A.C.C., Oct. 1868).

C. glaucum L. (*Oak-leaved Goosefoot*)
Roadsides and waste places. Introduced. Rare.
(8) St. David's, on ballast heaps (B. & S.); Charlestown (J.B.S., Aug. 1837, R.B.G.).

C. Bonus-Henricus L. (*Good King Henry*)
Roadsides and hedges. Rather common.

Beta Linn.

B. maritima L. (*Sea Beet*)
Seacoast. Very rare.
(3) Crail (G.S.); Elie (J.H.B., 1863) (W.Y., 1920); (4) Largo (now extinct); (7) between Kirkcaldy and Kinghorn (Brodie, R.B.G.) (A.H.G., 1883, now extinct); (8) Donibristle (J.H.B., 1849); St. David's (1836) (Fraser, 1904).
First record: Sibbald, (3) Isle of May, as "*Beta marina.*"

Atriplex Linn.

A. littoralis L. (*Grass-leaved Sea Orache*)
Waste ground near the sea. Frequent.
First record: Lightfoot, "about Dysart Dock" (7).

var. **marina** (L.)
(8) St. David's (A.C.C., 1865).

A. patula L. (*Halbert-leaved Orache*)
Seashores or inland. Common.
(2) St. Andrews (D.-H.); (3) Crail (G.S.); Isle of May (G.W.); (4) Balcarres (C.G.); (9) Orwell parish (N.S.A.).

var. **erecta** (Huds.)
(2) St. Andrews (J.H.B.); (3) Crail (G.S.); east of Elie (J.H.B.); (8) St. David's (A.R., 1835, R.B.G.).

var. **angustifolia** (Sm.)
(2) St. Andrews; (4) Kilconquhar and Colinsburgh (W.); (7) Kirkcaldy (W.Y.); (8) St. David's (B. & S.); near Inverkeithing (A.R.); Dunfermline parish (N.S.A.).

var. **bracteata** Westerl.
(8) N. Queensferry (A. Dewar, 1836, R.B.G.).

A. hastata L.
(1) Balmerino (J.C.); (3) Crail (G.S.); (4) Kilconquhar (B. & S.); (7) Kirkcaldy (A.H.G.); (8) N. Queensferry (Greville, 1836).

A. deltoidea Bab.
Very rare.
(8) St. David's (A.C.C., Sept. 1867).

A. Babingtonii Woods (*A. rosea* Bab.)
Seashores. Common.

A. laciniata L.
Very rare.
(2) Tents Muir (R.S.); St. Andrews (D.-H.); (3) East Neuk (W.); (7) Seafield and Burntisland (B. & S., as *A. arenaria*); (8) Inchcolm (M.); Port Laing (K.N.S., 1836); Inverkeithing (A.R.); Dunfermline parish (N.S.A.).

A. portulacoides L.
Doubtful records.
(3) East Neuk (W.); Prof. Trail, without locality

Salicornia Linn.

This genus needs critical study.

S. europaea L. agg. (*Jointed Glasswort*)
Muddy seashores. Not common.
(1) Near Tayport (R.S.); (2) Eden mouth (G.W.); (4) Cocklemill Burn (W.); (8) Donibristle (B. & S.); Dalgety

Bay (R.S.); Inverkeithing (A.R., 1835); Charlestown and N. Queensferry (A.C.C.).

First record: Greville, "Inverkeithing Bay, Neill."

Suaeda Forsk.

S. fruticosa Forsk.

Doubtful records.

(8) Dalgety Bay (R.S., 1896); St. David's (A.C.C., Oct. 1868).

S. maritima Dum. (*Damort, Sea Blite*)

Coast. Not common.

(2) Mouth of Eden; (3) Crail (G.S.); Kilrenny (N.S.A.); (4) Largo Bay (W.Y.); (7) Burntisland (J. M'Nab, 1836); (8) St. David's (K.N.S., Dewar, 1836); Inverkeithing (J.H.B.); N. Queensferry (1837, R.B.G.).

Salsola Linn.

S. Kali L. (*Prickly Saltwort*)

Sandy seashores. Frequent.

POLYGONACEAE.

Polygonum Linn.

P. Convolvulus L. (*Climbing Buckwheat, Black Bindweed*)

Widely distributed. Frequent.

P. aequale Lindman

(9) Kinross (G. C. Druce, 1912, Trans. Bot. Soc. Edin., Vol. xxvi, p. 150).

P. aviculare L. (*Knot Grass*)

Fields and waste places. Very common. The forms of this variable species need investigation.

var. **arenastrum** (Bor.)

Very rare.

(3) Elie (J. W. Brown, 1862); (7) Dysart (A.H.G.); (8) Inverkeithing (R.B.G., 1840).

var. **rurivagum** (Jord.)

(J.B.S., 1871, R.B.G., no locality).

var. **litorale** (Link)

(3) Caiplie, Crail (G.S., 1896); east of Elie (J.H.B.); (8) Inverkeithing (B. & S.).

var. **boreale** Lindman
(9) Shore of Loch Leven (J.R.M., as *P. heterophyllum* Lindm. var. *boreale* Lindm.).

P. Raii Bab.
Very rare.
(1) Seashore near Tayport (1858); (3) Elie Harbour (W.); (4) Largo Bay (J. Knapp, 1837, R.B.G.).

P. maritimum Linn.
Very rare. Needs verification.
(3) Elie Harbour (W.).

P. Hydropiper L. (*Water Pepper, Biting Persicaria*)
Sides of lakes, ponds, and ditches. Common.

P. minus Huds.
Shores of lochs. Rare.
(7) Kirkcaldy (W.Y.); (9) Loch Leven (W.A., & Sonn.).

P. Persicaria L. (*Spotted Persicaria*)
Moist waste places. Common.

P. lapathifolium L.
Damp waste places. Common.

P. maculatum Trim. et Dyer (*P. nodosum* auct.)
Damp gravelly places. Rare.
(8) St. David's (A.C.C., 1868); Charlestown (A.C.C., 1871); (9) Loch Leven (J.B.S., 1871).

P. amphibium L. (*Amphibious Bistort*)
Sides of ponds and lakes. Common.

P. Bistorta L. (*Bistort, Snakeweed*)
Moist meadows. Frequent.

P. viviparum L. (*Viviparous Alpine Bistort*)
Hilly pastures. Frequent.

Fagopyrum Hill

F. sagittatum Gilib. (*F. esculentum* Moench) (*Buckwheat*)
Rubbish heaps. Escape from cultivation.
(3) Crail (G.S.); west of Anstruther (J.H.B.); (7) Kirkcaldy (B. & S.); (8) near Inverkeithing (A.R.); near N. Queensferry (D., 1837).

Oxyria Hill

O. digyna Hill (*O. reniformis* Hook.) (*Mountain Sorrel*)
(2) Lomond Hill (Sonn.).

Rumex Linn.

R. conglomeratus Murr. (*R. acutus* Sm.) (*Sharp Dock*)
Wet places. Common.

R. sanguineus L. (*Bloody-veined Dock*)
Shady places and roadsides. The records no doubt refer in most instances to the var. *viridis*.

var. **viridis** (Sibth.)
Common.
(2) Dairsie and Earlshall (B.); (4) near Largo (W.); (7) between Dysart and Wemyss (J.H.B.); (8) Aberdour Woods (J.H.B., 1852); Culross (Sonn.); (9) Rumbling Bridge (J.H.B.).

R. maritimus L. (*Golden Dock*)
Marshes near the sea. Rare. Records need verification.
(1) Balmerino (J.C.); (3) Elie (W.); (4) Kincraig (N.S.A.); (7) Kinghorn and Burntisland (B. & S.); (8) St. David's (A.C.C., 1868); Charlestown (A.C.C., 1871).

R. limosus Thuill. (*R. palustris* Sm.)
Marshy places. Very rare. Records need verification.
(1) Balmerino (J.C.); (7) between Kinghorn and Pettycur, and Burntisland (J.H.B.).

R. obtusifolius L. (*Broad-leaved Dock*)
Roadsides and waste places. Common.

R. crispus L. (*Curled Dock*)
Waste places. Common.
First record: Sibbald, "Inchkeith, Common Dock."

var. **subcordatus** Warren
(3) Crail coast (G.S., 1911): (7) Balmuto (J.B.S., 1874).

× **obtusifolius** (*acutus* L.)
(8) Inverkeithing (K.N.S., 1836, A.D.); (9) Kinross.

R. domesticus Hartm. (*R. aquaticus* L.)
Moist places. Frequent.

× **obtusifolius** (*conspersus* Hartm.)
(7) Balmuto (J.H.B.); (9) Crook of Devon (J.B.S., 1870, R.B.G.); Loch Leven (W.A.).

R. Hydrolapathum Huds. (*Great Water-dock*)
Ditches and sides of streams. Frequent.

R. alpinus L. (*Alpine Dock*)
Roadsides, pastures. Introduced. Very rare.
(1) Near Tayport (Dr. Malcolm Wilson, 1934); (4) Kilconquhar (W.E.E.); (6) Loch Fitty (Sonn.); (8) Knock Hill, Dunfermline (Sonn.).
Specimen in R.B.G.Ed., leg. W. Brand, 1844, "Fife."

R. Acetosa L. (*Common Sorrel*)
Meadows and pastures. Very common.

R. scutatus L. (*Garden Sorrel*)
On old walls, amongst rocks. Rare. Garden escape.
(7) Burntisland; (8) Aberdour Old Castle (J.H.B., 1855).

R. Acetosella L. (*Sheep's Sorrel*)
Dry pastures. Very common.

ARISTOLOCHIACEAE.

Asarum Linn.

A. europaeum L. (*Asarabacca*)
Woods. Introduced. Very rare.
(7) Burntisland (J.H.B., 1856).

THYMELACEAE.

Daphne Linn.

D. Mezereum L. (*Common Mezereon*)
In woods. Introduced.
(1) Scotscraig (R.S., 1896), (3) Elie Woods (W.); (7) Dysart.

D. Laureola L. (*Spurge Laurel*)
In woods. Introduced.
(1) Balmerino (J.C.); Earlshall (G. Lawson); (3) Cambo (G.S.); Elie Woods (W.); (4) Kilconquhar (J.H.B., 1859); (7) Dysart (W.L.L., 1847, R.B.G.); Raith (J.H.B., 1867).

ELAEAGNACEAE.

Hippophae Linn.

H. Rhamnoides L. (*Sea Buckthorn*)
Seacoast. Introduced.
(3) Cambo (G.S.); (7) Burntisland (J.H.B.); (8) St. David's (W.Y.); near Aberdour (R.B.G., 1835).

EUPHORBIACEAE.

Euphorbia Linn.

E. Helioscopia L. (*Sun Spurge*)
Cultivated ground. Common.

E. amygdaloides L. (*Wood Spurge*)
Woods and thickets. Very rare.
(8) St. David's (A.C.C., 1889). Doubtful record.

E. Esula L. (*Leafy-branched Spurge*)
Woods and waste places.
(2) By River Eden, St. Andrews (M.); Tents Muir (J.H.B., 1854); "Edenside," 3 miles from St. Andrews (G. M'Nab, 1837, R.B.G.); (7) Burntisland (W.Y., 1935); (8) Aberdour (B. & S.).

E. Cyparissias L. (*Cypress Spurge*)
Very rare. Introduced.
(8) Dunfermline (B. & S.).

[**E. Paralias** L. (*Sea Spurge*)
Sandy seacoasts.
(1) Balmerino (J.C.); (3) East Neuk, "shore" (W.); (8) St. David's (A.R., 1834). Probably errors.]

[**E. portlandica** L.
Seacoasts.
(8) St. David's (A.R., 1834); Inverkeithing (N.S.A.). Probably errors.]

E. Peplus L. (*Petty Spurge*)
Cultivated and waste ground. Common.

E. exigua L. (*Dwarf Spurge*)
Cornfields in sandy soil. Not common.
(3) Boghall (G.S.); (4) Largo (F.C.C.), (7) Dysart (B. & S.); Kirkcaldy (W.Y.); Burntisland (Sonn.); Kinghorn parish (N.S.A.); (8) Aberdour (A.C.C.); Ferry Hills (A.R.); near Limekilns (J.H.B., 1850); near Dunfermline (Brodie, R.B.G.).
First record: Lightfoot, "Burntisland."

E. Lathyrus L. (*Caper Spurge*)
Woody places, cultivated ground. Rare.
(8) Pitreavie; Culross (A.R.); Inverkeithing (Dr. Dewar, 1836, R.B.G.); Dunfermline (N.S.A.).

Buxus Linn.

B. sempervirens L. (*Common Box*)
Woods. A garden escape, or planted. Rare.
(3) East Neuk (W.); (4) Balcarres (B. & S.).

Mercurialis Linn.

M. perennis L. (*Dog's Mercury*)
Woods and shady places. Very common.
First record: Leighton & Swan, 1840, Lindores.

M. annua L. (*Annual Mercury*)
Waste and cultivated land. Rare.
(7) Dysart (A.H.G., 1883); Burntisland (A. Dewar, 1836) (Fraser, 1902); (8) Inchcolm; St. David's (P. Ewing, 1885, R.B.G.); Aberdour and St. David's (J.H.B.); Charlestown (A.C.C., 1870).
First record: Lightfoot, "Burntisland."

URTICACEAE.

Ulmus Linn.

U. glabra Huds. (*U. montana* Stokes) (*Wych Elm*)
Woods and hedges. Common.
(1) Balmerino (R.S.); (3) Cambo (G.S.); (7) Kirkcaldy (A.H.G.); Burntisland (J.H.B.); (8) Pitreavie (W.L.L., 1849, R.B.G.).

U. campestris L. (*U. surculosa* Stokes) (*Common Elm*)
Woods and plantations.

Humulus Linn.

H. Lupulus L. (*Common Hop*)
Hedges and thickets. Introduced. Not common.
(1) Newburgh (J.H.B.); (7) Dysart and Wemyss (J.H.B., 1853); Wemyss Castle (A.H.G.); (8) Aberdour (A.C.C.); N. Queensferry (B. & S.).

Urtica Linn.

U. dioica L. (*Stinging Nettle*)
Waste places, etc. Very common.

U. urens L. (*Small Stinging Nettle*)
Waste places, etc. Very common.

U. pilulifera L. (*Roman Nettle*)
Waste places. Introduced.
(8) St. David's (A.C.C., 1880). Doubtful record.

Parietaria Linn.

P. ramiflora Moench (*P. officinalis* L. p.p.) (*Wall Pellitory*)
Old walls. Not common.
(1), (2), (3), (4), (7), (8).
First record: Lightfoot, "Burntisland."

MYRICACEAE.

Myrica Linn.

M. Gale L. (*Bog-myrtle*)
Marshes. Common.
First record: Sibbald, no locality.

CUPULIFERAE.

Betula Linn.

B. alba L. (*B. verrucosa* Ehrh.) (*Birch*)
Woods. Common.

B. tomentosa R. & A. (*B. pubescens* Ehrh.)
Woods. Frequent.

var. **denudata** E.S.M.
(7) Auchtertool Linn (W.L.L., 1819, R.B.G.).

Alnus Hill

A. rotundifolia Mill (*A. glutinosa* Gaertn.) (*Alder*)
Woods. Common.

Carpinus Linn.

C. Betulus L. (*Hornbeam*)
Woods and hedges. Not common.

Corylus Linn.

C. Avellana L. (*Hazel*)
Hedges and copses. Common.

Quercus Linn.

Q. Robur L. (*Common Oak*)
Woods and plantations. Common. Few records indicate which of the varieties is intended.

var. **pedunculata** (Ehrh.)
Recorded by Professor Trail (1903).

var. **sessifolia** (Salisb.)
Recorded by Professor Trail (1903).
(7) Dunnikier (A.H.G., 1882, R.B.G.).

Castanea Hill

C. sativa Mill. (*C. vulgaris* Linn.) (*Chestnut*)
Plantations. Frequent.

Fagus Linn.

F. sylvatica L. (*Common Beech*)
Woods and plantations. Common.

Salix Linn.

S. pentandra L. (*Bay-leaved Willow*)
Banks of streams. Frequent.

S. triandra L. (*Almond-leaved Willow*)
(2) Collessie (N.S.A.).

S. decipiens Hoffm.
Damp meadows. Rare.
(2) Near St. Andrews (Dr. F. B. White, A.S.N.H., 1889–90).

S. fragilis L. (*Crack Willow, Withy*)
Marshy places. Rare. Cultivated.
(2) Collessie (N.S.A.); (3) East Neuk (W.); Fife (B.W., Linn. Soc., 1890).

S. alba L. (*White Willow*)
Banks of streams. Common.

× **triandra** (*S. undulata* Ehrh.)
Recorded by Professor Trail (1906).

S. purpurea L. (*Purple Willow*)
Wet places. Rare.
(7) Raith (J.H.B., 1867).

S. viminalis L. (*S. stipularis* Sm.) (*Osier*)
Wet places. Occasional. Introduced.
(1) Balmerino (J.C.); (2) Collessie (N.S.A.).

S. caprea L. (*Great Sallow*)
Woods and hedges in dryish places. Common.

S. aurita L. (*Round-eared Sallow*)
Damp woods. Frequent.

S. cinerea L. (*Grey Sallow*)
Wet places. Frequent.

S. phylicifolia (L.) Sm. (*Tea-leaved Willow*)
Near streams. Rare.
(3) East Neuk (W.), no locality, " doubtful record," Trail.

S. repens L. (*Creeping Willow*)
Heaths and hills. Frequent but local.

S. fusca (Sm.)
Rare.
(2) Collessie parish (N.S.A.); (9) Orwell parish.

S. herbacea L. (*Least Willow*)
Summit of hills. Very rare.
(9) " Kinross-shire " (Walker Arnott n.d. R.B.G.).

Populus Linn.

P. alba L. (*White Poplar*)
Plantations. Common. Introduced.

× **tremula** (*P. canescens* Sm.)
(8) Donibristle (W.L.L., 1849).

P. tremula L. (*Aspen*)
Plantations. Common.

P. deltoides Marsh. var. **serotina** Hart.
Planted.
Recorded by G. C. Druce in Trans. Bot. Soc. Edin., 1912, without locality.

EMPETRACEAE.

Empetrum L.

E. nigrum L. (*Crowberry*)
Heaths and hills. Frequent.

CERATOPHYLLACEAE.

Ceratophyllum L.

C. demersum L. (*Common Hornwort*)
Streams, ponds, and ditches. Uncommon.

(2) St. Andrews (J.H.W.); Tents Muir (B.); (4) Dunbarnie Links (W.); (8) Otterston Loch (W.Y.).

C. submersum L. (*Unarmed Hornwort*)
Lochs. Very rare.
(9) Loch Leven (Sonn.).

CONIFERAE.

Juniperus Linn.

J. communis L. (*Common Juniper*)
Hills and heathy pastures. Rare.
(1) Dhu Craig; (2) Green Hill, Falkland (C.G.); (3) East Neuk (W.); (6) Cardenden (A.H.G., 1883, R.B.G.).

Taxus Linn.

T. baccata L. (*Common Yew*)
Woods and plantations. Common.

Pinus Linn.

P. sylvestris L. (*Scotch Fir*)
Woods. Common.

MONOCOTYLEDONS.

HYDROCHARIDACEAE.

Elodea Michx.

E. canadensis Michx. (*Water Thyme*)
Lochs, ponds, and ditches. Common. Introduced.
(1) Scotscraig (R.S., 1893); (4) near Elie (B. & S.); Dunglass (B. & S.); (6) Loch Fitty (G.W.); (7) Bogie Pond (W.Y., 1935); (9) Loch and River Leven (W.Y.).

ORCHIDACEAE.

Malaxis Soland.

M. paludosa Sw. (*Bog Orchis*)
Sphagnum bogs. Very rare and sporadic.
(2) St. Andrews (L. & S.); (4) Largo Links (W.); (8) Inverkeithing (N.S.A.); Queensferry Hills (Jas. Dewar, 1836); Ferry Hills (R.B.G., 1837); near Dunfermline

(N.S.A.); (9) Cleish Hills (A.R.); near foot of Dunglow (D. Stewart).

First record: Lightfoot, "found in some marshes near St. Andrews, but we do not affirm it from our own knowledge."

Corallorrhiza Châtel.

C. trifida Châtel. (*C. innata* Br.) (*Coral-root*)

Marshy ground. Very rare.

(2) Tents Muir (R.S., 1893, and W.Y., 1931–33); (8) near Dunfermline (1835, R.B.G.) and near Limekilns (J.H.B., 1866); Culross Woods (A. Hunter, 1836, R.B.G.); (9) side of Loch Leven (W.E., 1908).

Neottia Adans.

N. Nidus-avis Rich. (*Bird's Nest*)

Shady woods. Very rare.

(1) Birkhill Woods (R.S., 1898); (7) Chapel near Kirkcaldy (W.Y.); Burntisland (B. & S.); (8) Broomhall and Donibristle (A.T., 1919); (9) Blairadam (A.R. & D., 1835; A.T., 1919); Rumbling Bridge (J.H.B.).

Listera Br.

L. cordata Br. (*Heart-leaved Tway-blade*)

Heathy, hilly places. Rare.

(2) Tents Muir (J.H.B.); near Cupar (J.H.B.); Lucklaw Hill and Drumcarro Crag (B.); West Lomond Hill (J.H.B., 1855) (A.H.G., 1883, R.B.G.); (3) Crail Curling Pond (G.S.); (7) Kinghorn (N.S.A.); (8) Knock Hill (B. & S.); Culross (D., 1835); (9) near Carnbo (D.).

L. ovata Br. (*Common Tway-blade*)

Woods and moist pastures. Common.

Goodyera Br.

G. repens Br. (*Peramium repens* Salisb.)

Fir woods. Very rare.

(1) St. Fort (R.S., 1893); (2) near Ladybank (W.Y., 1905).

Cephalanthera Rich.

C. longifolia Fritsch (*C. ensifolia* Rich.) (*White Helleborine*)

Woods and sunny slopes. Very rare.

(8) Leckerstone (K.N.S., June 1840) (Dr. Dewar, R.B.G.); Broomhall (B. & S.).

Helleborine Hill (*Epipactis* Adans.)

H. latifolia Druce (*Broad-leaved Helleborine*)

Meadows and pastures. Uncommon.

(8) Inverkeithing (A.R.); Pitreavie (R.S., 1896); (9) by Loch Leven (R.S., 1897); Cleish parish (A.R.).

H. longifolia Rend. et Britt. (*E. palustris* Crantz) (*Marsh Helleborine*)

Moist places. Very rare.

(3) Innergellie, near Elie (B.), "now drained"; east of Anstruther (Campbell, 1834, R.B.G.); near Crail (J. Knapp, 1836, "very fine," R.B.G.); Kilrenny (W.).

First record: Hooker, 1 mile east of Anstruther, Chalmers.

Orchis Linn.

O. pyramidalis L. (*Pyramidal Orchis*)

Pastures and waste places. Very rare.

(3) West of Anstruther (J.H.B., 1864); Elie Links (W.); (4) Lundin Links (G.S.); Leven Links (J. Knapp, 1835, R.B.G., "confirming the locality as the original station for Scotland"); Largo (B. & S., "among bent in sand"); (6) Kinglassie Woods (C.H., white flowers, doubtful record).

O. mascula L. (*Early Purple Orchis*)

Woods and pastures. Fairly common.

O. incarnata L.

Marshes. Frequent.

(3) Elie (J.H.B.); (4) Largo Links (J.H.B., 1863, and W.Y., 1921); Kilconquhar Loch (W.).

O. latifolia L. (*Marsh Orchis*)

Marshes and moist meadows. Status uncertain. All records need investigation; they probably refer to *O. incarnata* L. or *O. purpurella* T. et T. A. Stephenson, in most instances.

O. maculata L. (*Spotted Palmate Orchis*)

Woods, pastures, heaths. Common.

O. purpurella T. et T. A. Stephenson

(2) Lomond Hills (Druce); (7) railway embankment between Kinghorn and Burntisland (W.Y., 1936).

Aceras Br.

[**A. anthropophora** Br. (*Green-man Orchis*)
Only record (without locality) is by Sibbald, and is no doubt an error.]

Ophrys Linn.

[**O. fuciflora** Reichb. (*O. arachnites* Lam.) (*Spider Orchis*)
Recorded by Wood in his "East Neuk of Fife" without locality. Clearly an error.]

Habenaria Willd.

H. conopsea Benth. (*Fragrant Gymnadenia*)
Moist pastures. Rare.
(1) Logie parish (N.S.A.); (2) Falkland, Ladybank, and Cupar (J.H.B.); Edensmuir (L. & S.); Kinkell Cliffs; (3) Caiplie (W.); Crail (W.Y.); Anstruther; (4) Largo (G.S.); (8) Ferry Hills and Dunfermline (A.R.); Knock Hill (J.H.B.); Pitreavie (R.S.); Kincardine (J.H.B.); (9) Cleish and Orwell parishes (N.S.A.); Benarty and Lomond Hills (J.H.B.); near Kinross (Phyt. II).
First record: Greville, "Hills near the toll, N. Queensferry, Neill."

H. albida Br. (*Small White Orchis*)
Hilly pastures and heaths. Not common.
(2) Prior Moor, Tents Muir; (6) Cardenden (B. & S.); (8) Lethan's Glen (A.R.); Knock Hill (J.H.B.); by Black Devon (J.H.B.); (9) Cleish and Lomond Hills; near Orwell (B.); near Carnbo (D.).
First record: Greville, Ferry Hills, "a single plant."

H. viridis Br. (*Frog Orchis*)
Dry hilly pastures. Frequent.
First record: Greville, "about Burntisland and on Dunearn Hill."

H. bifolia Br. (*Lesser Butterfly Orchis*)
Woods, meadows, marshy places. Frequently recorded, but the records no doubt include *H. virescens* Druce and require verification.

H. virescens Druce (*H. chloroleuca* Ridl., *H. chlorantha* Bab.).
Pastures, heaths, and woods. Not common.
(2) West Lomond Hill (W.Y.); (7) Dysart Woods (W.W.E.,

1842, R.B.G.); (8) Knock Hill (J.H.B.); near Torryburn (J.H.B.); banks of Black Devon (J.H.B.); (9) Benarty, etc. (J.H.B.); Carnbo (R.B.G., 1839); Orwell parish (N.S.A.).

IRIDACEAE.

Iris Linn.

I. foetidissima L. (*Iris, Gladdon*)
Woods and thickets. Introduced.
(8) Fordel Woods (A.R., 1835); Inverkeithing (N.S.A.).
First record: Sibbald, no locality, as "*Moraea foetidissima.*"

I. Pseudacorus L. (*Yellow Water Iris, Flag*)
Watery places. Common.

AMARYLLIDACEAE.

Narcissus Linn.

N. Pseudo-Narcissus L. (*Common Daffodil, Lent Lily*).
Woods and pastures. Rare. Introduced.
(7) Burntisland (B. & S.); (8) Culross (K.N.S., 1845); Dunfermline (B. & S.).

N. poeticus L. (*Poet's Narciss*)
Near country houses as an escape. Very rare.
(2) Banks of Eden (W.G.S., 1885); (7) Dysart Woods (J.H.B., 1852); (8) near Inverkeithing (M., 1837; J.H.B., 1872).

Galanthus Linn.

G. nivalis L. (*Snowdrop*)
Woods and pastures. Introduced.
(1) Lindores Abbey (N.S.A.); Balmerino (J.C.); Ballinbreich (A.L.); (3) Cambo (G.S.); Balcarres Woods (C.G.); Elie Woods (W.); (8) Culross, Pitreavie, near Saline, and Inverkeithing (N.S.A.).

LILIACEAE.

Ruscus Linn.

R. aculeatus L. (*Butcher's Broom*)
Woods and heathy places. Introduced. Rare.
(7) Dysart Woods (J.H.B., 1849); Raith (J.H.B., 1870,

and W.Y., 1886 and 1936); Burntisland (J.H.B.); (8) Fordel (K.N.S., 1836).

Polygonatum Hill

P. multiflorum All. (*Solomon's Seal*)

Woods. Very rare. Introduced.

(7) Balmuto (W.Y., 1885); Dysart (B. & S.); (8) Inverkeithing (W.E.E.).

Convallaria Linn.

C. majalis L. (*Lily of the Valley*)

Woods. Introduced. Rare.

(1) Balmerino (J.C.); (2) St. Andrews (J.H.B.); (3) Pitmilly Links (B.); (7) Dysart (J.H.B., 1848); (8) Pitreavie (old garden); (9) Cleish (old garden).

First record: Sibbald, (9) Scotlandwell.

Allium Linn.

A. Scorodoprasum L. (*Sand Garlic*)

Sandy woods and fields. Very rare.

(2) Edenside, St. Andrews; (3) Pitmilly Links; Elie (G.S.); (8) Donibristle (G.S.); N. Queensferry (J.H.B.); St. David's (Brand, R.B.G.) (A.R., 1834); Pitreavie (A.R. & Dr. Wallich, 1834).

A. vineale L. (*Crow Garlic*)

Cornfields, waste places. Frequent.

A. oleraceum L. (*Garlic*)

Borders of fields. Rare. Records need verification.

(1) Near Forgan (W.G.S.); (2) St. Andrews (B.); Earlshall (B.); (8) St. David's (Stewart).

First record: Hooker, St. David's.

A. carinatum L.

Very rare.

(8) St. David's (A.R., 1837).

A. Schoenoprasum L. (*Chives*)

Very rare.

(8) Inverkeithing (J.H.B., 1849); N. Queensferry (Sadler, 1871).

A. ursinum L. (*Broad-leaved Garlic*)

Damp woods and hedges. Not common.

(1) Lindores (N.S.A.); Balmerino (J.C.); Birkhill Woods and near Forgan (W.G.S.); (2) Earlshall (W.Y.); Kinkell Cliffs (J.H.W.); Tents Muir (R.S.); (3) Cambo (G.S.); (7) Kirkcaldy (W.Y.); (8) Inverkeithing (J.H.B.).

Muscari Mill.

M. racemosum Lam. et DC. (*Grape Hyacinth*)
Sandy fields. Very rare.
(1) Balmerino (J.C.); (7) Dysart Woods (J.H.B.); (8) Otterston (H. Cleghorn, 1839, R.B.G.).

Scilla Linn.

S. verna Huds.
Pastures. Very rare.
(1) Birkhill Woods (R.S., 1898). A doubtful record.

S. non-scripta Hoffmgg. et Link (*S. nutans* Sm.) (*Wild Hyacinth*)
Woods and hedge-banks. Common.
First record: Sibbald, without locality.

Ornithogalum Linn.

O. umbellatum L. (*Star of Bethlehem*)
Meadows and pastures. Introduced. Rare.
(1) Logie parish (N.S.A.); (2) Forret Den, Cupar (L. & S.); (7) Kirkcaldy (W.Y.); Dysart Woods (B. & S.); (8) Pitreavie (A.R. & A.D., 1836); Donibristle (B. & S.); (9) Kinross-shire (H. & A.).

O. pyrenaicum L.
Woods. Casual.
(3) Kenly Den (G.S.).

Lilium Linn.

L. Martagon L. (*Turk's-cap Lily*)
Woods. Very rare. Introduced.
(7) Dysart Woods (J.H.B., 1853); (8) Broomhall Woods (J.H.B., 1848).

Tulipa Linn.

T. sylvestris L. (*Tulip*)
Open woods. Very rare.
(1) Balmerino (J.C.); (4) Largo House (naturalised); (7)

near Burntisland (B. & S.); (8) Donibristle (W.Y., 1885); Otterston (J.H.B., 1833); Pitreavie (A.R.); Dunfermline and Inverkeithing (N.S.A.).

Gagea Salisb.

G. lutea Gawler (*G. fascicularis* Salisb.)

Woods and thickets. Very rare.

(1) Logie (N.S.A.); (2) Forret Den, Cupar (J. Sadler, 1873, R.B.G.); (7) Auchtertool Linn (Miss Boswell, 1822 and 1840; J. Knapp, 1836; J. Sadler, 1873; Dr. Lloyd, 1885 (Kew Herb.)), now extinct in this locality.

First record: Hooker, (2) Forret Den, near Cupar.

Narthecium Huds.

N. ossifragum Huds. (*Bog Asphodel*)

Moors and bogs. Common.

First record: Greville, (8) North Queensferry.

Paris Linn.

P. quadrifolia L. (*Herb Paris*)

Damp woods. Very rare.

Without locality (L. & S.); (8) Inverkeithing (N.S.A.); Hillside Dene (D., 1834, R.B.G.); Black Devon and Blairhill Woods (B. & S.); (9) Cleish Hills (A. Hunter, 1836, R.B.G.); Rumbling Bridge (J.H.B.).

JUNCACEAE.

Juncus Linn.

J. bufonius L. (*Toad Rush*)

Marshy and wet places. Common.

var. **fasciculatus** (Bert.)

Very rare.

(1) Lindores Loch (G.W.); (6) Loch Fitty (G.W.); (8) Town Loch (G.W.); (9) Loch Leven (J.B.S.).

J. squarrosus L. (*Heath Rush*)

Heaths and moors. Common.

J. compressus Jacq. (*Round-fruited Rush*)

Damp places. Rare.

(1) Balmerino (J.C.); (3) Crail (G.S.); Kilrenny parish (N.S.A.); (4) Kilconquhar Loch (N.S.A.); (8) Inverkeithing (A.R., 1837).

J. Gerardi Lois.
Salt marshes. Very rare.
(1) Beach near Ballinbreich Castle (A.L.); (2) Tents Muir (J.H.B., 1858); St. Andrews (G.W.); (3) Crail (W.Y., 1891); (7) Pettycur (W.W.E., 1846); (8) Inverkeithing (B. & S.).

J. balticus Willd.
Sandy and wet seashores. Rare.
(1) Boggy land near Tayport (C. H. Robinson); (2) Tents Muir (L. & S. and A.T., 1919); near Leuchars (F.C.C., 1904, R.B.G.).
Also recorded in J. of B. (1913) by R. S. Adamson without locality.

J. filiformis L.
Very rare.
(2) St Andrews, by Rock and Spindle (J.H.W.).

J. inflexus L. (*J. glaucus* Ehrh.) (*Hard Rush*)
Wet places on seashore. Rare.
(2) Tents Muir (R.S.); St. Andrews (G.W.); (3) Crail (G.S.); (4) Kilconquhar (B.); Dunbarnie Links (C.G.).
First record: Lightfoot, "coast."

J. effusus L.
Marshy ground. Common.

× **inflexus** L. (*diffusus* Hoppe)
(4) Cocklemill Burn (G.S., 1891); (8) Kincardine (J.H.W.).

J. conglomeratus L.
Marshy ground. Common.

× **inflexus** L.
(3) Crail (G.S.).

J. maritimus Lam. (*Lesser Sharp Sea-rush*)
Salt marshes and seashores. Rare.
(2) Near St. Andrews (B., & M.); (3) Boarhills (W.Y.).

J. fluitans Lam.
(1) Morton Loch (G.W.).

J. bulbosus L. (*J. supinus* Moench)
Boggy and wet places. Frequent.

J. subnodulosus Schrank
Marshy places. Rare.
(3) East Neuk (W.).

J. articulatus L. (*J. lampocarpus* Ehrh.)
Boggy ground. Common.

J. sylvaticus Reich. (*J. acutiflorus* Ehrh.)
Ditches and marshy places. Common.

J. triglumis L.
Boggy places on hills. Very rare.
(9) Ochil Hills (Dewar, 1839), without locality. It is doubtful whether it is within the bounds of Fife and Kinross.

Luzula Willd.

L. pilosa Willd. (*L. vernalis* DC.)
(1) Balmerino (J.C.) (R.S., 1898); Birkhill Woods (R.S., 1893); (3) East Neuk (W.); (7) Balmuto (W.Y.); Dunnikier (A.H.G., 1882); (8) Lethan's Glen (A.R.); (9) Cleish Hills (R.S., 1900).

L. sylvatica Gaud. (*L. maxima* DC.)
Woods. Common.

L. campestris DC. (*Field Wood-rush*)
Dry pastures. Very common.

L. multiflora DC. (*L. erecta* Desv.)
Dry pastures. Rare.
(1) Lindores Loch (F.M.W.); Balmerino (J.C.); (2) Ramornie (N.S.A.); (3) Kingask (G.S.); (9) Lomond Hills (J.H.B., 1855).

var. **congesta** Lej.
Often occurs along with the type.

L. nivea DC.
Introduced.
(8) Broomhall near Dunfermline (Dr. Dewar and A.T., 1919); Charlestown (J.H.B. 1848; J. Duncanson, 1866, R.B.G.).

TYPHACEAE.

Typha Linn.

T. latifolia L. (*Great Reed-mace*)
Sides of lochs and ponds. Native, but probably planted in most places. Frequent.

T. angustifolia L. (*Lesser Reed-mace*)
Ponds and ditches. Rare.
(1) Lindores Loch (Stark, 1835) (G.S.); (7) Raith Lake (J.H.B., 1870).

Sparganium L.

S. erectum L. (*S. ramosum* Curt.)
Sides of streams and ditches. Frequent, but the records no doubt often refer to *S. neglectum* Beeby.

var. **microcarpum**
Very rare.
(7) Burntisland Reservoir (G.W.).

S. neglectum Beeby
Wet places.
(7) Balmuto (J.B.S., R.B.G.).

S. simplex Huds. (*Bur-reed*)
Ponds and ditches. Status uncertain, records no doubt include *S. neglectum* Beeby.
First record: Greville, "lake on summit of Dunearn Hill."

var. **longissimum** Fr.
(6) Loch Fitty (G.W.).

S. affine Schnizl. (*S. natans* L.)
(2) Clatto Reservoir (G.W.); Tents Muir; (3) Crail (G.S.); (8) Aberdour (K.N.S., 1837).
First record: Hooker, (7) Dunearn Hill.

S. minimum Fr.
(8) Pool on Craigluscar Hill, near Dunfermline (A.T., 1919).

ARACEAE.

Arum Linn.

A. maculatum L. (*Cuckoo Pint, Lords and Ladies*)
Woods and hedge-banks. Uncommon.
(3) Cambo (G.S.); Crail (W.Y.); (4) Balcarres Den (W.); (7) Dysart (B. & S.); (8) Inverkeithing (A.R.); Pitreavie (A.R.); Limekilns (J.H.B.); Culross (N.S.A.); (9) Dowhill, Kinross (A.C.C.); Cleish Castle (A.R.).

LEMNACEAE.

Lemna Linn.

L. trisulca L. (*Ivy-leaved Duckweed*)
Clear stagnant waters. Rare.
(1) Calais Moor (R.S.); (3) Kilconquhar Loch (C. Howie, 1858, and G.W.) (abundant); (7) Kinghorn Loch (B. & S.); (8) Otterston Loch (G.W.).

L. minor L. (*Lesser Duckweed*)
Stagnant waters. Very common.

L. gibba L.
Ponds and ditches.
(9) Loch Leven (doubtful record).

ALISMACEAE.

Alisma Linn.

A. Plantago-aquatica L. (*Greater Water Plantain*)
By sides of lochs and ponds. Common.

var. **graminifolium** Wahl.
Rare.
(1) Lindores Loch, and (6) Lochgelly Loch (G.W.).

A. ranunculoides L. (*Lesser Water Plantain*)
Lochs, ponds, ditches, bogs. Rare.
(1) Lindores Loch (G.W.); (2) Tents Muir; (7) near Burntisland (G. Don); (8) Lochhead, Dunfermline, and Ferry Loch (A.R., 1836); (9) Loch Leven (J.H.B., 1855; G.W.); Orwell parish (N.S.A.).
First record: Greville, "near Burntisland, G. Don."

Sagittaria Linn.

[**S. sagittifolia** L. (*Arrow-head*)
(3) East Neuk (W.), the only record and very doubtful.]

NAIADACEAE.

Triglochin Linn.

T. palustre L. (*Marsh Arrow-grass*)
Bogs and marshy meadows. Common.

T. maritimum L. (*Seaside Arrow-grass*)
Salt marshes. Frequent round the coast.

Potamogeton Linn.

P. natans L. (*Broad-leaved Pondweed*)
Lochs, ponds, and ditches. Common.

P. polygonifolius Pourr. (*P. oblongus* Viv.)
Lochs, ponds, and ditches. Common.

P. coloratus Hornem. (*P. plantagineus* Du Croz)
Rare.
(1) Lindores Loch (A.L.).

P. alpinus Balb. (*P. rufescens* Schrad.)
(1) Lindores Loch (B.W., 1879); (4) Kilconquhar Loch (G.W.); (6) Cardenden (J.H.B. & J. M'Nab); Loch Fitty (G.W.); (7) near Kirkcaldy (J.H.B.); (8) Dunfermline parish (N.S.A.); reservoirs between Dunfermline and Saline (G.W.).
var. **spathulifolius** Fischer
(1) Black Loch (G.W.); (9) Cleish Hills (G.W.).

P. lanceolatus Sm.
Recorded by L. & S. without locality; (8) Knock Hill (J.H.B., 1852).

P. heterophyllus Schreb. (*P. gramineus* Fries)
Ponds and ditches. Not common.
(1) Lochmill Loch (J.H.B.); (3) St. Monans Burn (W.); (5) Harperlees Reservoir (G.W.); (6) Loch Fitty (Dr. Dewar, 1834); (7) Balmuto (Misses Boswell, R.B.G.); Dysart grounds (B. & S.); (8) Carnock Moor (N.S.A.); Black Loch (B. & S.); (9) Loch Leven (J.H.B., 1860, & G.W.); Lomond Hills (J.H.B.).
var. **terrestris** Schlecht.
(9) Loch Leven (G.W.).

P. nitens Weber
Recorded by Professor Trail without locality (A.S.N.H.), also collected by Dr. Playfair, confirmed by A. Bennett, without locality.

P. lucens L. (*Shining Pondweed*)
(1) Lochmill Loch (G.W.); (6) Loch Gelly (A.R. & J.B.S.); (7) Kinghorn Loch (A.R.); Burntisland Reservoir (G.W.); Dunfermline (B. & S.); (9) Loch Leven (G.W.).

P. angustifolius B. & P. (*P. Zizii* Koch)
(1) Lindores and Mill Lochs (G.W.); (6) Loch Fitty (G.W.); (7) Kinghorn Loch (J.B.S., 1873, R.B.G.; (8) Burntisland Reservoir and Otterston Loch (G.W.); (9) Loch Leven (G.W.).

P. praelongus Wulf. (*Long-stalked Pondweed*)
(1) Lindores Loch (R. H. Meldrum, 1886); Black Loch (G.W.); loch behind Tayport (B. & S.); (6) Loch Fitty (G.W.); loch at foot of Dunglow (D. Drummond); (7) Burntisland (G. M'Nab); Kinghorn Loch (Dr. Lowe, 1853); (9) Cleish Hills (R.S.); Loch Leven (G.W.).

P. perfoliatus L.
Frequent.
var. **lanceolatus** Blytt
(2) Ballomill, Collessie parish (N.S.A.).

P. crispus L. (*Curly Pondweed*)
Streams and ditches. Frequent.
var. **serratus** Huds.
Very rare.
(7) Kinghorn Loch (G.W.).

P. densus L.
Very rare.
(5) Ballo and Harperlees Reservoirs (W.Y , 1926).

P. zosterifolius Schum.
(6) Loch Gelly (B. & S.).

P. obtusifolius Mert. et Koch
(1) Lindores Loch (R.H.M., 1886); Lochmill Loch (G.W.); (2) Morton Loch (G.W.); (4) Kilconquhar Loch (G.W.); (6) Loch Fitty (G.W.); (9) Loch Leven (G.W.).
var. **fluvialis** Lange et Mort.
(7) Burntisland Reservoir (G.W.).

P. Friesii Rupr.
(6) Loch Gelly (J.B.S., 1818).

P. pusillus L.
Frequent.

P. panormitanus Biv.-Bern.
(9) Loch Leven (G.W.).

P. pectinatus L.
Rare.
(3) Kilconquhar Loch (G.W.); (6) Gelly and Fitty Lochs (G.W.); (7) Camilla Loch (J.B.S.); Kinghorn Loch (G.W.); (8) Dunfermline Reservoir (B. & S.); Loch Carnock (J.H.B.).

P. interruptus Kit. (*P. flabellatus* Bab.)
(8) Dunfermline Town Loch (G.W.).

P. filiformis Nolte
Frequent.
var. **alpina** Blytt
(6) Loch Gelly (G.W.).

Ruppia Linn.

R. rostellata Koch
Salt marshes. Very rare.
(4) Burton Point (G.S.).

Zannichellia Linn.

Z. palustris L. (*Horned Pondweed*)
Floating.
(2) Tents Muir (M. & B.); Kinness Burn (J.H.W.); (3) Crail (G.S.); (4) Kilconquhar Loch (W.); Leven (R.S.); (6) Loch Fitty (A.R.); Cardenden Burn (B. & S.); Camilla Loch (W.Y., *fide* A. Bennett); (8) Otterston Loch (G.W.).
var. **brachystemon** (Gay)
(4) Kilconquhar Loch (G.W.).

Zostera Linn.

Z. marina L. (*Broad-leaved Grasswrack*).
(2) Eden estuary (G.W.); Tents Muir (R.S.); (7) Pettycur and Burntisland (A.R.); (8) Inverkeithing (M.); Aberdour (A.C.C.).
var. **angustifolia** Hornem. (*Z. Hornemanniana* Tutin)
(7) Burntisland (J.B.S., 1874).

Z. nana Roth
Recorded by Professor Trail without locality (A.S.N.H.).
(8) Near Torryburn (W.E., Trans. Bot. Soc. Edin., 1889).

Naias Linn.

N. flexilis Rostk. et Schm.

Deep lochs.

(1) Lindores Loch. Planted by Dr. F. Buchanan White and Col. Drummond Hay, 1878.

CYPERACEAE.

Eleocharis Br.

E. acicularis Roem. et Schult. (*Least Spike-rush*)

Damp places on heaths. Rare.

(1) By Lindores and Lochmill Lochs (G.W.); (6) by Loch Gelly (A.R.); (7) Camilla (J.B.S.) and Kinghorn Lochs (A.R.); (8) Carnock Moor (A.D.); (9) Loch Leven (A.R.).

First record: Hooker, Loch Leven, as "*Scirpus acicularis*."

E. palustris Roem. et Schult. (*Creeping Spike-rush*)

Marshy edges of ponds. Frequent.

E. uniglumis Schultes (*Single-glumed Spike-rush*)

Wet sandy places. Rare.

(2) Shore between Guardbridge and Tents Muir (F.M.W., 1876, R.B.G.); (3) near Crail (G.S.); Isle of May (G.W.); (9) Loch Leven (W.Y.).

E. multicaulis Sm. (*Many-stalked Spike-rush*)

Marshy places. Rare.

(1) Balmerino (J.C.); (2) Tents Muir (W. Barclay, 1886); (3) Saughur (W.); (8) near Dunfermline (D., 1836); Knock Hill (J.H.B.).

Scirpus Linn.

S. pauciflorus Lightf. (*Chocolate-headed Club-rush*)

Bogs and turfy ground Not common.

(2) Near St. Andrews (J.H.W.); (3) Crail (W.); (4) Kilconquhar Loch (W.); (5) Falkland (B. & S.); (8) St. David's (J.H.B.); Aberdour (B. & S.); Inverkeithing (D., 1836); N. Queensferry (B. & S.); (9) Lomond Hills (J.H.B.); Loch Leven and Cleish Hills (J.H.W.).

First record: Hooker, (9) Loch Leven.

S. caespitosus L. (*Scaly-stalked Club-rush*)

Moist heathy places. Uncommon.

(1) Forgan Bog (R.S.); (2) Prior Moor (J.H.W.); (3) Crail

(G.S.); (4) Largo Links; (8) Ferry Hills (A.R., 1837); Moss Morran (A.H.G.); Saline Hills (A.R.); Loch Larg (G.W.); (9) Lomond Hills (B. & S.).

S. fluitans L. (*Floating Club-rush*)

Marshes. Uncommon.

(3) Isle of May (W.E., 1879); (4) Kilconquhar Loch (N.S.A.); (7) marsh at top of Dunearn Hill (Neill); (8) N. Queensferry (A.C.C.) (W.E., 1909).

S. filiformis Savi (*S. Savii* Seb. et Maur.)

(5) Leslie, and (9) Loch Leven (P. Ewing, 1882).

S. setaceus L. (*Bristle-stalked Club-rush*)

Moist, gravelly, and sandy places. Common.

S. lacustris L. (*Bulrush*)

Lochs and ponds. Status doubtful, the records no doubt refer largely to *S. Tabernaemontani* Gmel.

S. Tabernaemontani Gmel. (*Glaucous Club-rush*)

In still waters. Common.

(1) Tayside, 4 miles below Newburgh (B.W.); (4) Kilconquhar Loch (G.S.); (8) Knock Hill (J.H.B., 1852).

First record: Hooker, "River Tay at Newburgh."

S. maritimus L. (*Sea Club-rush*)

Marshy seashores. Uncommon.

(1) Near Newburgh (R.H.M., 1886); Balmerino (J.C.); near Wormit and Tayport (R.S.); (2) Tents Muir (J.H.B.); Eden estuary (J.H.W.); (3) Boarhills (G.S.); Crail (W.); (4) east of Largo (J.H.B.); (8) St. David's (R.B.G.); near Inverkeithing (N.S.A.); near Charlestown (R.S.); near Torryburn (J.H.B.); Culross (R. Greville, 1836).

S. sylvaticus L. (*Wood Club-rush*)

Damp woods and on river-banks. Frequent.

S. compressus Pers. (*Broad-leaved Blysmus*)

Boggy pastures. Rare.

(3) Crail (W.Y.); (4) Largo Links (C.G., J.H.W.); (8) Starleyburn (A.R.).

S. rufus Schrad. (*Narrow-leaved Blysmus*)

Marshes near the sea. Not common.

(2) St. Andrews (D.-H.); (3) Crail (W.Y.); (7) Kinghorn; (8) near N. Queensferry (W.B., 1887); Starleyburn (A.R.).

Eriophorum Linn.

E. vaginatum L. (*Hare's Tail Cotton-grass*)
Bogs and moors. Common.

E. angustifolium Roth (*Narrow-leaved Cotton-grass*)
Moors and turfy bogs. Common. Records of *E. polystachion* R. probably should be included here.

E. latifolium Hoppe
Bogs and heathy places. May occur, but status doubtful.

E. capitatum *sine auct.*
(1) Newburgh (N.S.A.). Probably a form of *E. vaginatum* L.

Rhynchospora Vahl

R. alba Vahl (*White Beak Rush*)
Moors. Very rare.
Only record, " Fife " (1837, R.B.G., leg. W. Croze).

Schoenus Linn.

S. nigricans L. (*Black-headed Bog-rush*)
Boggy moors. Rare.
(1) Forgan Bog (R.S.); (3) near Anstruther (J. Knapp, 1835); (4) Dunbarnie Links (W.Y., 1920); Largo Links (J.H.B., 1865).
First record: Greville, " Bog east of Anstruther, Dr. Graham."

Cladium P. Br.

C. Mariscus Br. (*Fen Sedge*)
Bogs.
(2) Tents Muir (B.). Very doubtful record.

Carex Linn.

C. dioica L.
Spongy bogs. Not common.
(2) Tents Muir (R.S.); (3) Kenly Den (G.S.); (9) Lomond Hills (B. & S.); Orwell parish (N.S.A.).

C. pulicaris L. (*Flea Sedge*)
Boggy places. Frequent.
(1) Balmerino (J.C.); (2) Drumcarro Crag (B.); near Ramornie (N.S.A.); Tents Muir (R.S.); near St. Andrews (J.H.W.); (3) Kenly Den (G.S.); near Elie (J.H.B.); (6)

near Lochgelly (B.); (8) Inverkeithing (A.D., 1836); (9) Lomond Hills (J.H.B.); Benarty (W.Y., 1926).

C. pauciflora Lightf.

Rare.

(1) Logie (M.); (8) Knock Hill (J.H.B., 1852); (9) Lomond Hills (J.H.B.).

C. incurva Lightf.

Rare.

(2) Tents Muir (J.H.B., 1854, A.T., 1912, and Dr. Malcolm Wilson, 1934), St. Andrews Links (Lightf. Fl. Scot.); (3) near Elie (J.H.B.); (4) Largo Links (W. Stewart).

var. **erecta** Lange

(2) Tents Muir (A.T., 1919).

C. disticha Huds.

Frequent in all districts.

C. arenaria L.

Frequent round the coast in sandy places.

C. diandra Schrank (*C. teretiuscula* Good.)

Bogs. Rare.

(1) Forgan Bog (R.S.); (3) Boarhills (G.S.); (4) Kilconquhar Loch (G.S.); Largo (J.H.B.); (8) Otterston Loch (K.N.S., 1836; A.T., 1919); near Dunfermline (J.H.B.); Black Loch (J.H.B.).

First record: Greville, (8) N. Queensferry (T. Mackay).

C. paniculata L.

Bogs. Not common.

(1) Forgan Bog (R.S.); (3) Boarhills (G.S.); (4) Largo (J.H.B.): Kilconquhar Loch (W.); (6) Loch Gelly (G.W.); (8) Otterston Loch (K.N.S., 1836, and G.W., 1908); near Limekilns (J.H.B.); N. Queensferry (Hook.).

C. vulpina L.

Wet shady places. Common.

First record: Greville, "between Pettycur and Kinghorn, on the seaside by a spring."

C. muricata L.

Wet gravelly pastures. Very rare.

(3) Crail (G.S.); (8) Aberdour (K.N.S., 1836); Inverkeithing (A.D.); near Dunfermline (P. N. Fraser, R.B.G.).

C. divulsa Stokes
Moist shady places. Very rare.
(8) Fordel (B.).

C. echinata Murr. (*C. stellulata* Good.)
Marshy and heathy places. Common.

C. remota L.
Damp shady places. Rather rare.
(2) St. Michael's Wood, Leuchars (M.); (8) Aberdour (K.N.S., 1836); near Limekilns and Culross (J.H.B.); (9) Rumbling Bridge (J.H.B.).

C. curta Good. (*C. canescens*, auct. non Linn.)
Marshy places. Common.
First record: Hooker, (8) "N. Queensferry, Maughan."

C. leporina L. (*C. ovalis* Good.)
Meadows and boggy places. Common.

C. elata All. (*C. stricta* Good., *C. caespitosa* L.)
Marshes. Rare.
(4) Kilconquhar Loch and Dunbarnie Links (W.); (8) Dunfermline parish (N.S.A.): (9) Lomond Hills (J.H.B.).
First record: Greville, (9) "Marsh to west of N. Queensferry, G. Don."

C. gracilis Curt. (*C. acuta* auct.)
Very rare.
(3) Kilconquhar Loch (W.); (6) Loch Gelly (K.N.S., 1840); (8) N. Queensferry (G. Don).

C. aquatilis Wahl.
Margins of lochs and ponds. Rare.
(4) Kilconquhar Loch (J.H.B.); (6) Loch Fitty (G.W.); (7) Burntisland Reservoir (G.W.); (8) Dunfermline (A.D., 1840).
var. **elatior** Bab.
(8) Dunfermline (Dr. Playfair, 1900, R.B.G.).

C. Goodenowii Gay (*C. vulgaris* Fr.)
Wet pastures and heaths. Common.

C. flacca Schreb. (*C. glauca* Scop.)
Damp meadows and woods. Common.

C. magellanica Lam. (*C. irrigua* Sm.)
Spongy bogs. Very rare.

(8) Foot of Knock Hill, Dunfermline (J.H.B., 1852); (9) Lochs Lurg and Dow, Cleish Hills (A.T., 1919).

C. limosa L.

Bogs. Very rare.

(1) Forgan Bog (R.S., 1893); Balmerino (J.C.); (8) Otterston Loch (Dr. Graham, 1835, R.B.G.); Inverkeithing (N.S.A.); (9) Lochs Lurg and Dow (A.T., 1919).

C. pilulifera L.

Wet moory places. Common.

C. caryophyllea Latourr. (*C. verna* Chaix, *C. praecox* Jacq.)

Dry pastures. Common.

C. pallescens L.

Marshes. Rare.

(3) East Neuk (W.); (8) Ferry Loch (A.D., 1836); Dunfermline (B. & S.); near Limekilns (J.H.B.); (9) Ochil Hills (B. & S.).

C. panicea L.

Marshy places. Frequent.

C. pendula Huds.

Damp woods. Very rare.

(2) On River Moutray near Lucklaw Hill (M.); Edensmuir (N.S.A.).

C. strigosa Huds.

Damp woods. Very rare.

(8) Dunfermline parish (N.S.A.).

C. sylvatica Huds.

Moist woods. Frequent.

C. helodes Link (*C. laevigata* Sm.)

Marshes and boggy woods. Rare.

(4) Kilconquhar Loch (W.); (6) Carden Den (D., 1840, K.N.S.); by River Ore near Thornton (J.H.B.); (7) Dysart (B. & S.); (8) near Dunfermline (J.H.B., 1837); near Limekilns (J.H.B.).

C. binervis Sm.

Dry heathy ground. Frequent.

C. distans L.

Marshy places. Frequent.

C. fulva Host (*C. Hornschuchiana* Hoppe)
Boggy places. Rare.
(1) Balmerino (J.C.); (2) Falkland (B. & S.); (3) Devil's Cave (W.); (8) Aberdour (D., 1836, K.N.S.); Inverkeithing and N. Queensferry (J.H.B.); Dunfermline (M.); Lethan's Moor (D.); (9) Lomond Hills (J.H.B.).

C. extensa Good.
Wet places. Rare.
(2) Near St. Andrews (Greville and R. Dow, 1889); Rankeillour (W.Y., 1889); (3) near Elie; (4) Dunbarnie Links (B.); (7) Burntisland (J.H.B.); (8) Starleyburn (G. M'Nab); Aberdour (R.B.G., 1834); Otterston Loch.
var. **pumila** And.
(3) Crail (W.Y.).

C. flava L.
Wet places. Common.
var. **lepidocarpa** (Tausch)
(7) Orrock Hill (J.S.B., 1870).

C. Oederi Retz.
Turfy bogs. Rare.
(1) Tents Muir (R.H.M., 1886); (6) Loch Gelly (J.B.S.); (8) Inverkeithing (D., 1836, K.N.S.); (9) Orwell parish (N.S.A.).

C. lasiocarpa Ehrh. (*C. filiformis* "Linn.")
Boggy meadows and hills. Very rare.
(1) Lindores Loch (B.W. in S.N., 1879); Forgan Bog (R.S., 1894).

C. hirta L.
Wet pastures. Common.

C. acutiformis Ehrh. (*C. paludosa* Good.)
Wet places. Common.

C. riparia Curt.
Wet places. Uncommon.
(2) Edensmuir (N.S.A.); (2) East Neuk (W.); (4) Kilconquhar Loch (W.); (8) Lethan's Dene (D., 1844, K.N.S.).

C. inflata Huds. (*C. ampullacea* Good.)
Marshes and bogs. Common.

C. vesicaria L.
Sides of streams and lochs. Records need verification.

GRAMINEAE.

Panicum Linn.

P. Crus-galli L.
Introduced. Very rare.
(8) Charlestown (T. Drummond, 1871, R.B.G.); St. David's (A.C.C., 1869).

Setaria Beauv.

S. viridis Beauv.
Casual.
(1) Tayport (G. Law, 1858); (3) East Neuk (W.); (7) Burntisland Docks (F.M.W., 1878, R.B.G.); (8) St. David's (A.R., 1834, "one plant"); Charlestown (T. Drummond, 1871, R.B.G.).

Spartina Schreb.

S. Townsendi (H. & J. Groves)
(8) Near Kincardine (W.G.S.), "planted in 1914."

Phalaris Linn.

P. canariensis L.
Waste places. Introduced. Frequent.

P. arundinacea L.
Sides of lochs and streams. Common.

Anthoxanthum Linn.

A. odoratum L. (*Vernal Grass*)
On sunny grassy places. Common.

A. aristatum Boiss.
Introduced. Very rare.
(7) Inchkeith (A.C.C., 1885).

Alopecurus Linn.

A. myosuroides Huds. (*A. agrestis* L.)
Fields and waysides. Uncommon. Casual.
(3) Near Elie (J.H.B.); (8) St. David's (A.D., 1836, K.N.S., and A.C.C., 1867).

A. aequalis Sobol. (*A. fulvus* Sm.)
Ponds and ditches. Introduced. Rare.
(1) Balmerino (J.C.); (3) Elie Harbour (W.).

A. geniculatus L.
Wet meadows. Common.

A. bulbosus Gouan
Salt marshes. Rare.
(1) Balmerino (J.C.).

A. pratensis L. (*Meadow Foxtail Grass*)
Meadows and pastures. Common.

Milium Linn.

M. effusum L. (*Spreading Millet Grass*)
Damp woods. Uncommon.
(1) Balmerino (J.C.); (2) Urquhart, near West Lomond Hill (L. & S.); (7) Dysart Woods (B. & S.); (8) Lethan's Glen, Culross Woods, Knock Hill, by Black Devon (1837), and near Limekilns (J.H.B.); (9) Rumbling Bridge (J.H.B.).

Phleum Linn.

P. pratense L. (*Timothy Grass*)
Meadows and pastures. Common.
var. **nodosum** (Linn.)
(4) Kincraig Braes (W.).
var. **stoloniferum** Bab.
(8) Donibristle (M'T. Cowan, Jr., 1912).

P. arenarium L. (*Sea Cat's-tail Grass*)
Sandy places near the sea. Common.
First record: Hooker, (7) Burntisland.

Agrostis Linn.

A. canina L. (*Brown Bent-grass*)
Moist heaths. Common.

A. alba L. (*Marsh Bent-grass*)
In pastures and by roadsides. Common.
var. **stolonifera** (Linn.)
(1) Newport (J. Knapp, 1836); (2) Cults Hills (N.S.A.); (8) Ferry Hills (A.R.).
var. **coarctata** (Hoffm.)
(8) St. David's (M'T. Cowan, Jr., 1911).

A. tenuis Sibth. (*A. vulgaris* With., *A. pumila* Lightf.)
Meadows. Common.

Polypogon Desf.

P. monspeliensis Desf.
Salt marshes. Rare.
(3) East of Elie (J.H.B., 1864); Elie Harbour (W.); (7) Burntisland (A.H.G., 1883); (8) St. David's (A.R., 1834).

Calamagrostis Adans.

C. epigeios Roth (*Small Reed*)
Damp shady places. Very rare.
(8) Charlestown (W.E.E., 1902–1904); St. David's (J.H.B., 1851).

C. canescens Druce (*C. lanceolata* Roth)
Wet places. Rare.
(3) East Neuk (W., as *Arundo Calamagrostis* L.)

Apera Adans.

A. Spica-venti Beauv. (*Wind-grass*)
Sandy fields. Rare.
(7) Burntisland (A.H.G., 1883); (8) St. David's (D., 1837); near Dunfermline (B.); Charlestown (A.C.C., 1871).

Ammophila Host (*Psamma* Beauv.)

A. arenaria Link (*Marram* or *Bent*)
Sandy seashores. Common.
First record: Greville, "between Burntisland and Pettycur as *Arundo arenaria*."

Aira Linn.

A. caryophyllea L. (*Silvery Hair-grass*)
Pastures. Common.
var. **aggregata** (Tim.)
(2) St. Andrews (C. Howie, 1852, R.B.G.).

A. praecox L. (*Early Hair-grass*)
Sandy places on coast. Common.

Deschampsia Beauv.

D. caespitosa Beauv. (*Tufted Hair-grass*)
Meadows, thickets, etc. Common.

D. setacea Richter (*D. discolor* Roem. et Schult.)
Wet turfy bogs. Very rare.
(9) Cleish Hills (R.S., 1900).

D. flexuosa Trin. (*Wavy Hair-grass*)
Heathy and hilly places. Common.

Holcus Linn.

H. mollis L. (*Creeping Soft-grass*)
Pastures and hedges. Common.

H. lanatus L. (*Meadow Soft-grass*)
Meadows and pastures. Common.

Trisetum Pers.

T. flavescens Beauv. (*T. pratense* Pers.) (*Yellow Oat-grass*)
Fields. Frequent.

Avena Linn.

A. pubescens Huds. (*Downy Oat-grass*)
Pastures, rocks, etc. Common.

A. pratensis L. (*Narrow-leaved Oat-grass*)
Dry pastures. Common.

A. strigosa Schreb. (*Bristle-pointed Oat-grass*)
Cornfields. Rare.
(8) Inverkeithing (D., 1836; K.N.S.)

A. fatua L. (*Wild Oat, Haver*)
Fields. Rare.
(3) East of Crail (G.S.); near Elie (W.)

Arrhenatherum Beauv.

A. elatius Mert. et Koch (*A. avenaceum* Beauv.)
Hedges and pastures. Common.

Sieglingia Bernh.

S. decumbens Bernh. (*Decumbent Heath-grass*)
Dry banks and heaths. Common.
First record: Hooker, (1) Newburgh, as "*Poa decumbens.*"

Phragmites Adans.

P. communis Trin. (*Common Reed*)
Edge of waters. Common.

Sesleria Scop.

S. coerulea Ard. (*Blue Moor-grass*)
Hilly and heathy places. Very rare.
(1) Wormit Braes (R.S., 1894); (2) Tents Muir (R.S., 1894).

Cynosurus Linn.

C. cristatus L. (*Crested Dog's-tail Grass*)
Dry pastures. Common.

Koeleria Pers.

K. glauca DC. var. **arenaria** (Dum.)
(2) Pilmour Links (C. Bailey, 1882).

K. gracilis Pers.
Very rare.
(3) Crail (G.S., 1889).
var. **britannica** Domin (*K. cristata* auct.)
Uncommon.
(1) Mare's Craig (A.L.); near Tayport (R.S.); (2) St. Andrews (W.); (4) Kincraig (J.H.B., 1849); (8) St. David's (J.H.B.); N. Queensferry (B. & S.).

Molinia Schrank

M. coerulea Moench (*M. varia* Schrank) (*Purple Molinia*)
Wet heaths and hills. Frequent.
(2), (3), (4), (8), (9).
var. **depauperata** Lindb.
(8) Dunfermline (J.H.B.), and recorded by Prof. Trail without locality.

Catabrosa Beauv.

C. aquatica Beauv. (*Water Whorl-grass*)
Ponds and ditches. Not common.
(2) Drumcarro Crag (B.); Clatto Reservoir (W.B., 1888); (3) Crail (W.Y.); (4) Kilconquhar (G.S.); Largo Law (B.); (8) near Inverkeithing (A.D., 1836) (P.N.F., 1859); Dunfermline (B. & S.).

Melica Linn.

M. montana Huds. (*M. nutans* auct.)
Hilly woods. Rare.
(7) Kinghorn (M.); (8) Blair Den (N.S.A.); Lethan's Glen (A.R., 1834).

M. nutans L. (*M. uniflora* Retz.)
Shady woods. Rare.
(7) Near Auchtertool (A.R.); Kinghorn; (8) Blair Den

and near Dunfermline (N.S.A.); Lethan's Dene and Kincardine (J.H.B.).

Dactylis Linn.

D. glomerata L. (*Cock's-foot Grass*)
Meadows, woods, etc. Very common.

Briza Linn.

B. media L. (*Common Quaking Grass*)
Meadows and banks. Common.

B. minor L.
Alien.
(7) Burntisland Docks (F.M.W., 1878).

Poa Linn.

P. annua L. (*Annual Meadow-grass*)
Very common everywhere.

P. alpina L.
On mountains. Very rare.
(2) East Lomond Hill (C.G., J.H.W.).

P. Balfouri Parn. var. **montana** (Parn.)
(9) Lomond Hills (J.H.B., 1855).

P. nemoralis L. (*Wood Meadow-grass*)
Woods, etc. Not common.
(1) Balmerino (J.C.); (2) Eden's Muir (L. & S.); Ladybank (J.H.B.); (3) East Neuk (W.); (9) Lomond Hills (J.H.B., 1855).

P. compressa L. (*Flat-stemmed Meadow-grass*)
Dry barren places, walls, etc. Uncommon.
(3) East Neuk (W.); (4) Largoward (J.H.W.); (7) Kinghorn (W.Y.).
var. **polynoda** (Parn.)
(8) North Queensferry (Parnell).

P. pratensis L. (*Smooth-stalked Meadow-grass*)
Pastures, etc. Common.
var. **subcoerulea** (Sm.)
Rare.
(3) Crail (G.S.); (7) Kirkcaldy (seashore), Greville.
First record: Hooker, as "*Poa pratensis* var. *minor.*"

P. trivialis L. (*Rough Meadow-grass*)
Meadows. Common.
var. **parviflora** Parn.
(3) Kingask Wood (G.S., 1890).

Glyceria Br.

G. fluitans Br. (*Flote-grass*)
Ditches and stagnant water. Common.

G. plicata Fr. (*G. fluitans* Sm.)
Stagnant water and wet places. Rare.
(2) Marsh beyond Spindle Rocks, St. Andrews (D.-H.); (8) Moss Morran (B. & S.).

G. aquatica Wahlb. (*Water Whorl-grass*)
Ponds and ditches. Common.

G. maritima Mert. et Koch (*Creeping Sea Hard-grass*)
Banks on seashore. Not common.
(2) Harbour, St. Andrews (D.-H., 1868).
First record: Greville, " about Kirkcaldy, at west end near bridge."
var. **riparia** Towns.
(3) Crail (W.Y.).

G. distans Wahlb. (*Reflexed Hard-grass*)
Sandy places near the sea. Rare.
(1) Tayport (R.H.M., 1886); (3) Elie (J.S., 1855); East Neuk (W.); (4) Largo Links (J.H.W.); (7) Burntisland (N.S.A.); (8) near Aberdour (H.C.W.); Inverkeithing (A.D, 1826, R.B.G., and H. C. Watson, 1831); near Torryburn (J. Knapp, 1837; Kincardine (J.H.B.).

G. Borreri Bab.
Very rare.
(3) Elie (J. W. Brown, 1862, R.B.G.).

G. rupestris E. S. Marshall (*G. procumbens* Dum.)
Probably introduced. Rare.
(3) Near Elie (J.H.B., 1864); (8) St. David's (A.C.C.); Inverkeithing (A.R.); Limekilns (T. Drummond, 1872).

Festuca Linn.

F. rigida Kunth
Dry places. Not common. *
(2) St. Andrews; (3) near Elie (J.H.B.); (4) Largo, top of

wall behind Largo House (G.S.); (7) near Pettycur (A.D., 1834); Burntisland (K.N.S., 1837); (8) St. David's (A.C.C.); Charlestown (A.D.).

First record: Hooker, (7) Burntisland, as "*Poa rigida.*"

F. rottboellioides Kunth

(1) Balmerino (J.C.); (2) St. Andrews (J.H.B.); (3) Crail and Elie Harbour (W.); east of Elie (J.H.B.); (7) Burntisland (K.N.S., 1836, and J.H.B., 1846); (8) North Queensferry (D.).

F. Myuros L. (*Wall Fescue-grass*)

Walls and sandy places. Rare.

(8) Inverkeithing (K.N.S., 1837); near N. Queensferry (B. & S.).

First record: Greville, " on hill by road between Inverkeithing and N. Queensferry, Neill."

F. bromoides L. (*F. sciuroides* Roth)

Dry pastures. Frequent.

F. ovina L. (*Sheep's Fescue-grass*)

Dry pastures. Common.

F. rubra L. (*Hard Fescue-grass*)

Sandy seashores. Common.

First record: Greville, " shores and islands of Firth of Forth, D. Don."

F. sylvatica Vill. (*Reed Fescue*)

(4) Kincraig Braes (W.); (9) Kinross-shire (Parn.).

F. pratensis Huds.

Wet meadows. Rare.

(3) Crail (G.S.); (4) Largoward (J. Knapp, 1836); (7) Kirkcaldy (W.Y.); Kinghorn (B. & S.); Burntisland (N.S.A.); (8) Port Laing (K.N.S., 1836); Ferry Hills (M.); Dunfermline (B. & S.).

× **Lolium perenne** (*F. loliacea* Curt.)

(4) Largo (J. Knapp, 1836); (7) Balmuto (J.B.S., 1871).

F. elatior L. (*Meadow Fescue*)

Woods and hedges. Rare.

(3) Kenly Den and Crail (G.S.); (7) Kirkcaldy (W.Y.); Pettycur (B. & S.); (8) near Aberdour (A.D., 1835, R.B.G.); N. Queensferry (Parn.); Dunfermline (J.H.B.).

var. **arundinacea** (Schreb.)
(8) St. David's (J.H.B.); N. Queensferry (W.L.L., 1849).

Bromus Linn.

B. giganteus L.
(3) East Neuk (W.).

B. ramosus Huds. (*B. asper* Murr.) (*Hairy Wood Brome-grass*)
Moist woods and hedges. Common.

B. erectus Huds. (*Upright Brome-grass*)
Fields and waste places. Not common.
(4) Kincraig Point (M.); (7) to east of Kinghorn (W.Y.); near Pettycur (Parn.); (8) near Dunfermline (Brand); N. Queensferry (A.C.C.).
First record: Greville, " between Kirkcaldy and Pettycur." Prof. Trail says " doubtful native."

B. madritensis L. (*B. rigidus* Roth)
" Casual," Trail.
(8) Charlestown (T. Drummond); near Inverkeithing (A.R.); St. David's (Dr. Wallich and A.R., 1834); (9) near Kinross (A.R.).

B. sterilis L. (*Barren Brome-grass*)
Waste ground and fields. Very common.

B. secalinus L. (*Smooth Rye Brome-grass*)
Cornfields. Rare.
(2) Stratheden (L. & S.); (3) East Neuk (W.); (8) N. Queensferry (R. Parnell, 1844, R.B.G.).
First record: Hooker, " Fife coast."
var. **velutinus** (Schrad.)
(7) Kinghorn (J. Fraser, A.S.N.H., 1907, " alien "); (8) St. David's (A.C.C., 1866).
var. **divergens** Schb.
(7) Pettycur (Trail, alien).

B. racemosus L. (*Smooth Brome-grass*)
(8) N. Queensferry (Parn.).

B. commutatus Schrad. (*Tumid Field Brome-grass*)
Cornfields, roadsides. Frequent.

B. hordeaceus L. (*B. mollis* Linn.) (*Soft Brome-grass*)
Fields and pastures. Common.

var. **glabratus**
(1) Field, south end Lindores Loch (F.M.W., 1876, R.B.G.).
var. **ovalis** Dr.
(4) Largo Bay.

B. arvensis L. (*Taper Field Brome-grass*)
Fields and ballast heaps. Rare.
(3) East Neuk (W.); (8) Inverkeithing; N. Queensferry (R. Parnell, 1844, R.B.G.); " South Coast " (J. Fraser, 1904).

B. inermis Leyss.
Alien.
(7) Leven (J. M'A., 1912); (8) Inverkeithing (M., 1836).

Brachypodium Beauv.

B. sylvaticum Roem. et Schult. (*Slender False Brome-grass*)
Woods, banks, etc. Common.

B. pinnatum Beauv. (*Spiked Heath Brome-grass*)
Waste heathy places. Very rare.
(8) Near N. Queensferry (Greville " Neill ").

Lolium Linn.

L. perenne L. (*Beardless Rye-grass*)
Roadsides, pastures, etc. Common.
var. **multiflorum** (Lam.) (*L. italicum* Braun)
Fields and waste places. Introduced. Uncommon.
(1) Balmerino (J.C.); (3) East Neuk (W.); (4) Kilconquhar (B. & S.); (7) Kirkcaldy (W.Y.); (8) Ferry Hills and Kincardine (J.H.B.).

L. temulentum L. (*Darnel*)
Cornfields. Introduced.
(2) Collessie parish (N.S.A.); (3) Kilrenny (W.).
var. **arvense** (With.)
Occasional.
First record: " Fife," J. Knapp, 1838, R.B.G.

Agropyron J. Gaertn.

A. caninum Beauv. (*Fibrous-rooted Wheat-grass*)
Hedges and woods. Common.

A. repens Beauv. (*Couch-grass*)
Fields and roadsides. Very common.

A. pungens R. & S.
(8) St. David's (Fraser, 1910).
var. **dumetorum** Reichb.
(8) St. David's (Fraser, 1911).

A. junceum Beauv. (*Rushy Sea Wheat-grass*)
Sandy seashores. Common.

× **repens** (*acutum*, auct. angl.)
(2) St. Andrews (Sowerby's Eng. Bot. Ed., 3).

Lepturus Br.

L. filiformis Trin.
Seashores. Rare.
(8) St. David's (Dr. Wallich and A.R., 1834); Inverkeithing (T. Drummond, 1871, R.B.G.).

Nardus Linn.

N. stricta L. (*Mat-grass*)
Damp meadows and hillsides. Common.

Hordeum Linn.

H. nodosum L. (*H. pratense* Huds.)
Damp meadows. Occasional.
(2) Near St. Andrews (J.H.B., 1861); (3) East Neuk (W.); (8) near Torryburn (J.H.B., 1860); Kincardine (J.H.B.).

H. murinum L. (*Wall Barley*)
Waste ground. Common.

H. marinum Huds. (*H. maritimum* With.) (*Seaside Bennet*)
Sandy pastures near the sea. Frequent.

Elymus Linn.

E. arenarius L. (*Upright Sea Lyme-grass*)
Sandy seashores. Frequent.

E. sibiricus L.
Alien.
(7) Kinghorn (J. Fraser).

FILICES.

Hymenophyllum Sm.

H. tunbridgense Sm. (*Filmy Fern*)

Very rare.

(2) Lomond Hills (Dr. Lyell, 1856, R.B.G., a single frond, record doubtful).

H. peltatum Desv. (*H. unilaterale* Bory, *H. Wilsoni* Hook.)

Damp rocks. Very rare.

(2) West Lomond Hill (D. D. Arnott Sr., Kirkcaldy) (A.C.C., 1865) (J.H.B., 1861); Glen Queich (A. Curror, 1834, and W.A., 1839, R.B.G.); Crook of Devon ravine (A.R., Trans. Bot. Soc. Edin.).

Adiantum Linn.

[**A. Capillus-Veneris** L. (*Maiden-hair Fern*)

(3) East Neuk (W.); (4) Balcarres Den (N.S.A.). Both very doubtful records. No doubt *Asplenium trichomanes* L. was meant.]

Pteris Linn.

P. aquilina L. (*Bracken*)

Open woods and hillsides. Very common.

Cryptogramme Br.

C. crispa Br. (*Parsley Fern*)

Among loose stones on hills. Very rare.

(1) Balmerino (J.C.); (2) Drumcarro Crag (C.H.); West Lomond Hill (Maughan) (J.H.B., 1861); (7) Dunearn Hill (A.C.C., 1866); (8) Knock Hill (A.R.); (9) Saline Hills (J.H.B., 1848); Bishop Hill (W.Y., 1916); Ochil Hills (D., 1836).

Blechnum Linn.

B. Spicant With. (*Hard Fern*)

Woods and heaths. Common.

Asplenium Linn.

A. fontanum Bernh.

Walls and rocks. Very rare.

Recorded by Sibbald without locality as "*Polypodium fontanum.*" A very doubtful record.

A. Adiantum-nigrum L. (*Black Spleenwort*)
Rocks and walls. Frequent.
First record: Sibbald, "Coast."

A. marinum L. (*Sea Spleenwort*)
Crevices of rocks and caves by the sea. Frequent.
First record: Sibbald, (7) "Wemyss."

A. viride Huds. (*Green Spleenwort*)
Moist rocks on hills. Very rare.
(2) West Lomond Hill (B. & S., 1872); (9) Bishop Hill (W.Y., 1916, and A.T., 1919).

A. Trichomanes L. (*Maiden-hair Spleenwort*)
Rocks and walls. Frequent.
First record: Lightfoot, "Caves at Wemyss."

A. Ruta-muraria L. (*Wall Spleenwort*)
Walls and rocks. Common.
First record: Sibbald, "Caves at Wemyss."

A. germanicum Weiss
Rocks. Very rare.
(8) Near Dunfermline (Dr. Dewar, 1836).

A. septentrionale Hoffm. (*Forked Spleenwort*)
Clefts of rocks. Rare.
(1) Balmerino (J.C.).

Athyrium Roth

A. Filix-foemina Roth (*Lady Fern*)
Woods and moist places. Common.

Ceterach Willd.

C. officinarum Willd. (*Scale Fern*)
Old walls and rocks. Very rare.
(5) Near Leslie (J. Archibald).

Phyllitis Hill (*Scolopendrium* Adans.)

P. Scolopendrium Newm. (*S. vulgare* Symons) (*Common Hart's Tongue*)
Shady damp rocks and walls. Rare.
(1) Newburgh (M.); Lindores Abbey (A.L.); Birkhill (A.C.); (2) near Falkland (C.G.); St. Andrews Castle (J.H.W.); (3) Kenly Den (G.S., 1863), now extinct; Boarhills (M.); (7) Raith (Dr. Henderson), now extinct; near

Kirkcaldy, in mine air-shaft (W.Y.); Burntisland (J.H.B., 1856); (8) Aberdour (B. & S.).

Cystopteris Bernh.

C. fragilis Bernh. (*Bladder Fern*)
Rocks and walls. Frequent.
var. **dentata** Hook.
(1) Balmerino (J.C.); (3) near Crail (W.Y.); (4) near Largo (W.Y.).
var. **Dickieana** (Sim)
(2) Kinkell, St. Andrews (B.); (3) Airdrie Woods (W.).

Polystichum Roth

P. aculeatum Roth (*Bristly Shield Fern*)
Shaded rocky places. Not common.
(1), (3), (4), (7), (8), (9).
var. **lobatum** Presl
(8) Lethan's Glen (M.); (9) Cleish parish (N.S.A.).

[**P. Lonchitis** Roth (*Holly Fern*)
(4) Balcarres Den (W.). Very doubtful and, if correctly named, probably planted. Also recorded by L. & S. in Area 1—no doubt in error for the preceding species.]

P. angulare Presl (*Soft Shield Fern*)
(1) Birkhill and Balmerino (J.C.); (3) East Neuk (W.); (4) near Largo (J.H.B.). Also recorded by Professor Trail and by Ballingall. These records require verification.

Lastrea Presl

L. Thelypteris Bory (*Marsh Fern*)
(3) East Neuk (W.). Needs verification.

L. montana (T. Moore) (*L. Oreopteris* Presl) (*Sweet Mountain Fern*)
Heathy places. Frequent.
(1), (2), (3), (4), (8), (9).

L. Filix-mas Presl (*Male Fern*)
Woods and roadsides. Very common.
var. **affinis** Bab. (*incisa* T. Moore)
(4) Balcarres Den (W.); (7) Balmuto (J.B.S., 1875, R.B.G.);

Kirkcaldy (A.H.G., 1883, R.B.G.); (8) Aberdour (J.B.S., R.B.G.).

var. **Borreri** Newm.

(7) Balmuto (F. M. Webb, 1876, R.B.G.).

L. spinulosa Presl (*Narrow Prickly-toothed Fern*)

Marshy places and wet woods. Common.

L. aristata Rend. et Britt. (*L. dilatata* Presl) (*Broad Prickly-toothed Fern*)

Woods, moors, and roadsides. Common.

L. aemula Brackenridge

Rocky shady places. Very rare.

(4) Balcarres Den (W.); (7) Dunnikier (A.H.G., 1883, R.B.G.); Balmuto (J.B.S., 1875).

Polypodium Linn.

P. vulgare L. (*Common Polypody*)

Rocks, banks, trunks of trees, etc. Very common.

Phegopteris Presl

P. Dryopteris Fée (*Oak Fern*)

Woods and shady places. Frequent.

P. polypodioides Fée (*Beech Fern*)

Woods and damp shady places. Frequent.

Osmunda Linn.

O. regalis L. (*Royal Fern*)

(2) Rankeilour (W.Y., 1889); (8) Culross (A.R., 1834); near Torryburn (J.H.B., 1860); near Kincardine (A.D., 1848, R.B.G.).

Ophioglossum Linn.

O. vulgatum L. (*Adder's Tongue Fern*)

Moist pastures and woods. Rare.

(2) Cults lime quarries (L. & S.); Ceres parish (N.S.A.); Gateside (W.Y.); (3) East Neuk (W.); (6) Conland Farm (W.Y.); (7) Kinghorn parish (N.S.A.); Burntisland (B. & S.); (8) Aberdour and Torryburn (J.H.B.); Carnock (A.D.); Dunfermline (N.S.A.); (9) Blairadam (A.R.); Cleish (N.S.A.).

First record: Greville, (7) Balmuto.

Botrychium Sw.

B. Lunaria Sw. (*Moonwort Fern*)
Dry pastures. Frequent.
(1), (2), (3), (4), (7), (8), (9).
First record: Greville, (7) " Hills above Pettycur."

EQUISETACEAE.

Equisetum Linn.

E. maximum Lam. (*Great Water Horsetail*)
Wet places in woods. Not common.
(2) Cults parish (N.S.A.); Ceres parish (B.); (3) west of Crail (J. Knapp, 1843); Caiplie (W.); (4) near Kennoway (B. & S.); Largo Links (J. Knapp); (7) near Burntisland (R.B.G., 1847); (8) near Dunfermline (Dr. Graham, 1836, R.B.G.).

E. arvense L. (*Corn Horsetail*)
Fields, banks, and roadsides. Common.

E. pratense Ehrh. (*Blunt-topped Horsetail*)
Wet shady places. Rare.
(2) Lucklaw Hill (B.); (7) Raith (A.H.G.); (8) Carlin Hill and Lethan's Dene (J.H.B., 1839); (9) Lomond Hills (J.H.B.).

E. sylvaticum L. (*Wood Horsetail*)
Moist woods and hedge-banks. Common.

E. palustre L. (*Marsh Horsetail*)
Marshy places. Common.
var. **polystachyum** Weigel
(2) Tents Muir (B.).

E. limosum L. (*Smooth Naked Horsetail*)
Lakes, ponds, etc. Common.
var. **fluviatile** (Linn.)
(4) Kilconquhar Loch and Clatto Reservoir (G.W.); (7) Kinghorn Loch (G.W.).

E. hyemale L. (*Rough Horsetail*)
Moist banks and woods. Rare.
(1) Craighall Den (B.); (3) Kenly Den (B.); (4) north side of Largo Law by side of stream (B. & W.); (9) Cleish Hills and Blairadam (Trans. Bot. Soc. Edin., A.R.); near hillside, banks of Black Devon (R.B.G.).

E. variegatum Schleich. (*Variegated Rough Horsetail*)
Wet places near the sea. Rare.
(2) Tents Muir (C. Howie, 1861); St. Andrews (B.); (3) near Elie (J.H.B.); (4) Dunbarnie Links (B.).
var. **arenarium** Newm.
Very rare.
(3) Caiplie (W.); (4) Dunbarnie Links (W.).

LYCOPODIACEAE.

Lycopodium Linn.

L. Selago L. (*Fir Clubmoss*)
Heathy places on hills. Not common.
(2) Tents Muir and near Cupar (J.H.B., 1854); Lucklaw Hill (B.); Drumcarro Crag and Kingsmuir (C.H.); (5) Star Moss (A.H.G.); (8) Saline Hills (J.H.B., 1848); old quarry at Cullalo (W.E., 1897); (9) Lomond Hills (J.H.B.); Cleish Hills (A.R.).

L. inundatum L. (*Marsh Clubmoss*)
Boggy heaths. Very rare.
(2) Tents Muir (J.H.B., 1854).

L. clavatum L. (*Common Clubmoss*)
Heathy pastures. Rare.
(1) Lochmill Hill (A.L.); (2) near Cupar and Tents Muir (J.H.B.); Edensmuir (N.S.A.); Lucklaw Hill and Drumcarro Crag (C.H.); (7) Dunearn Hill (J.H.B.); (8) near Dunfermline (B. & S.) and Saline Hills; (9) Cleish parish (N.S.A.); Lomond Hills (J.H.B.).

L. alpinum L. (*Savin-leaved Clubmoss*)
(2) Lucklaw Hill and Drumcarro Crag (C.H.); hill near Cupar (J.H.B.); East Lomond Hill (C.G.); (9) Bishop Hill (A.C.C.); Cleish parish (N.S.A.).

SELAGINELLACEAE.

Selaginella Spring.

S. selaginoides Gray (*Lesser Alpine Clubmoss*)
Boggy places on hills and moors. Rare.
(2) Tents Muir (J.H.B.); St. Andrews Links (B.); West Lomond Hill (J.H.B.); (4) Dunbarnie Links (B.); (7) Kinghorn parish (N.S.A.); (9) Ochil Hills (D., 1838, R.B.G.).

Isoetes Linn.

I. lacustris L.
(9) Loch Leven (Hook.).

MARSILEACEAE.

Pilularia Linn.

P. globulifera L. (*Pillwort, Pepper-grass*)
Ponds and lochs. Very rare.
(2) West Lomond Hill (J.H.B., 1855); (9) Orwell (W.A.); Cuthil Muir (Hook.).

CHARACEAE.

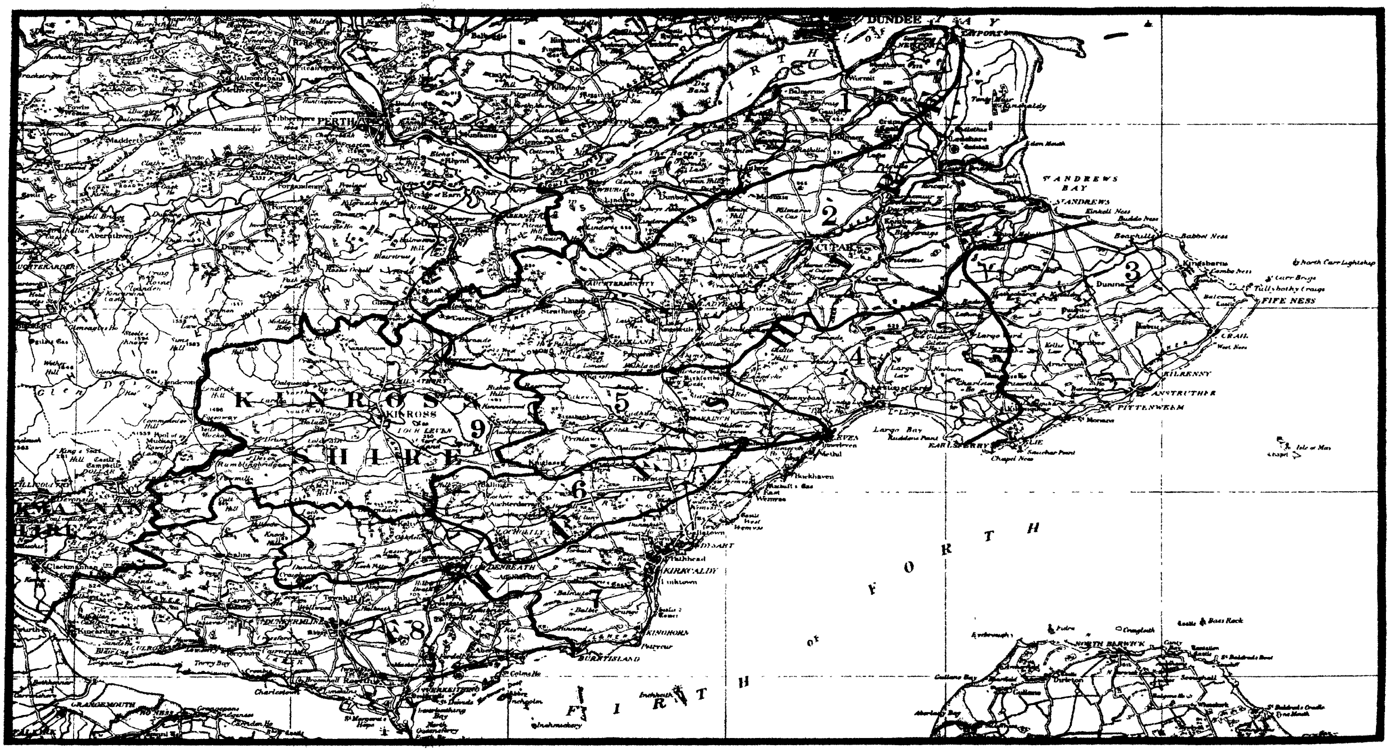
Chara Linn.

C. fragilis Desv.
Ponds and lochs. Not common.
(1) Morton Loch (G.W.); (3) Crail's Muir (G.S., 1886); (4) Hatton Reservoir (G.W.); (6) Loch Fitty (G.W.); (7) Burntisland Reservoir (G.W.); (8) Dunfermline Town Loch (G.W.).
var. **fulcrata** (Gant.)
(6) Loch Fitty (G.W.).
var. **delicatula** Braun
(1) Black Loch, Lochs Dow and Darg (G.W.); (5) Ballo Reservoir (G.W.); (6) Loch Fitty (G.W.).

C. aspera Willd.
Lochs and ponds.
(1) Lochmill Loch (G.W.); (6) Loch Fitty (G.W.); (9) Loch Leven (G.W.).
var. **capillata** Braun
(4) Kilconquhar Loch (G.W.); (6) Loch Fitty (G.W.).
var. **subinermis** Kuetz.
(6) Loch Fitty (G.W.); (9) Loch Leven (G.W.).

C. desmacantha G. & B.W.
Recorded by Groves without locality.

C. polyacantha Braun (*C. aculeolata* Kuetz.)
Ponds and ditches.
Recorded by Prof. Trail and by Groves without locality.



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C. contraria Kuetz.

Ponds and ditches.

(1) Morton Loch (G.W.); (6) Loch Fitty (G.W.); (7) Kinghorn Loch (G.W.).

var. **hispidula** Braun

(5) Lochgelly Loch (J. of B., 1890); (7) Camilla Loch (G.W.).

C. hispida L.

Ponds and ditches.

(1) Lochmill Loch (G.W.); (2) Tents Muir (B.); (3) Toldrie Quarry (G.S.); (7) Glassmount Hill (B. & S.); (8) Inverkeithing (K.N.S., 1837).

C. rudis Leonh.

(1) Lochmill Loch (G.W.).

C. vulgaris L.

(1) Morton Loch (G.W.); (2) Cults, near Priestfield (N.S.A.); (3) Balbathie Quarry Holes (W.); (4) Largo Links (J.H.B.); (7) Glassmount Marshes (B. & S.); Camilla and Kinghorn Lochs (G.W.); Burntisland (J.H.B., 1851); (8) Ferry Loch (K.N.S., 1836).

Tolypella Leonh.

T. glomerata Leonh.

Ponds and ditches.

(9) Loch Leven (G.W., " very scarce ").

Nitella Agardh

N. translucens Agardh

(7) Kinghorn, in ditches (B. & S.).

N. flexilis Agardh

(2) Tents Muir (B.); (7) Kinghorn Loch (B. & S.); (8) Loch Carnock (J.H.B.); Dunfermline (B. & S.); (9) Loch Leven (B. & S.).

N. opaca Agardh

(1) Morton Loch (G.W.); (2) Tents Muir (B.); (4) Carriston Reservoir (G.W.); (6) Loch Fitty (G.W.); (7) Burntisland Reservoir (G.W.); (9) Loch Leven (G.W.).

An Undescribed Structure in the Seed of the Broad Bean. By H. R. Orr, B.Sc., Ph.D. (With Pl. II.)

(Read 21st May 1936.)

The external appearance and general construction of the seed of the broad bean, *Vicia Faba* L., are too well known to require description, but during a prolonged investigation into the mechanism of absorption of liquids at germination, the writer discovered an anatomical feature which would appear to have been overlooked by previous workers in this field, and it seems to be of sufficient importance to merit description.

On the smooth outer surface of a ripe seed the most conspicuous feature is the hilum, the elongated scar left when the matured seed becomes detached from the funicle. At one end of the scar, next the embryonic root, is the micropyle, while at the opposite end, distal to the micropyle, is the termination of a vascular bundle which runs through the seed-coat. This bundle, described by Beck in 1878, is continuous with the vascular system of the funicle before its rupture, and doubtless constituted the pathway along which water and food were conveyed to the developing seed while it was still in the pod.

Immediately above the micropyle there is a V-shaped swelling which marks the position of the radicle of the embryo. The radicle lies in a pocket of the nutrient layer, in close proximity to the micropyle but always above it. This pocket fits closely round the radicle, more especially at the upper end where the radicle merges into the hypocotyl, which in turn is joined to the cotyledons. On the inner surface of the seed-coat, at either edge of the pocket which encloses the radicle, may be seen a half-moon shaped band which is dark brown in colour (fig. 1). These two bands lie on the innermost face of the nutrient layer and fit closely into the lateral sides of the radicle in the region of the hypocotyl. They differ from the neighbouring tissue in having a shiny appearance, and they are slightly raised above its level. When seen in surface view these bands have the semblance of a honey-

comb or network, with projecting cell-walls and sunken cavities, quite distinct from the smooth surface of the adjacent tissues. Microchemical tests of the bands themselves showed them to be of a cellulose nature.

When those parts of the hypocotyl in contact with the bands were examined, shallow hollows were found on the surface. These were similar in shape to the bands on the coat, and on microscopic examination it was observed that the cells in each sunken area are papillate. These papillate cells with their projecting outer wall would appear to fit closely into corresponding depressions in the bands on the seed-coat.

Sections were cut through the bands while the embryo was in its normal position, and also through the bands and hypocotyl separately. It was then confirmed that the cells in the sunken hypocotyl region did, in fact, fit closely into the raised bands of tissue on the inner face of the seed-coat, the ridges on the coat fitting into the hollows in the hypocotyl, and *vice versa* (fig. 2). From sections of the tissues cut separately it was seen that the flat-surfaced cells of the cotyledons merge into the papillate cells of the hypocotyl, which again pass into the smooth-surfaced cells of the root (fig. 3). In section, the tissue of the band on the inner surface of the seed-coat forms a serrated edge to the nutrient layer, in contrast to the adjacent, comparatively smooth surface (fig. 4). The serration is composed of thick projecting walls, which taper slightly towards the tips, with depressions between. The projecting walls fit in between the cells of the hypocotyl, locking the tissues of the coat and hypocotyl firmly together in that region.

The question now arises—what is the nature of the structure, and what purpose, if any, does it serve? In the life of a bean seed there are two entirely distinct phases of development during which the structure might function, namely, (*a*) maturation of the bean in the pod, and (*b*) germination of the seed. Both phases will have to be taken into consideration in order to discover the function or purpose of the structure. Some suggestions are therefore put forward concerning its uses, but further research into the developmental stages of the bean seed are necessary before definite proof of the truth of the theories can be offered, and these are being carried out at present.

From the general appearance of the structure in question, and the close contact that exists between the nutrient layer of the coat and the embryonic tissue, it would seem not improbable that the tissue of the bands had been at one time the means of conveying food from the nutrient layer to the embryo. Colour is lent to this theory by the fact that the cells of the hypocotyl and cotyledon appear to be elongated from the papillate region in the direction of the embryo. These cells might therefore act as a path for the easy diffusion of food through the tissue to the embryo, and to the plumule in particular (fig. 5). The idea behind this theory is that the structure was intended for the rapid transport of food from the nutrient layer to the embryo proper, in order to build up a concentrated food reserve in the embryo during maturation, especially in the later stages.

The vascular bundle, already mentioned as terminating at the hilar scar, is continued in the nutrient layer along the raphe, and it forks just before it reaches the embryo. The two branches thus formed subdivide further, and gradually lose their identity as they come into close proximity to the embryo, near to the bands on the coat. This might indicate that food was conveyed along the bundle to the vicinity of the bands, and from there it would pass into the hypocotyl, to be conducted to the embryo, along the path of elongated cells.

A second theory concerning the possible function of the structure might be suggested. Having regard to the nature of the bands, and their position just at the end of the pocket enclosing the radicle, is it not conceivable that they might act as clamps, holding the root in position, and so preventing it from moving during the drying or soaking of the seed? When the radicle begins to swell and to elongate during the first stages of germination, if it were not fixed at its base by clamps such as these, it might be prevented from growing forward by the mechanical barrier of the coat, and thus pressure would be set up backwards, which would put a strain on the hypocotyl region. The cotyledons being thus fixed in position, the strain on the hypocotyl would cause it to rupture, thus separating the root and plumule from the cotyledons, leading to the production of what is known in the terms of official seed analysis as a broken seedling. It would appear that the purpose of the bands, according to

this view, is to act as a clamp holding the radicle in position, and forcing it to grow forward, thus rupturing the coat, not *at* the micropyle as laid down by many authorities, but *above* the micropyle as actually happens. Naturally the coat acts as a barrier to the root because it is tough and some considerable force is required to rupture it. If the same force were applied to the much more delicate hypocotyl, which is mainly composed of soft parenchyma, there is little doubt that it would break. Therefore, if the clamping mechanism were not present to prevent the setting up of this backward pressure on the hypocotyl, a breakage in this region would be a frequent occurrence.

Attempts were made to prove the necessity for these clamping bands during the first stages of germination. A portion of the seed-coat, and the band immediately below, were removed from dry beans without causing any injury to the actual embryo itself. The beans, thus treated, were then soaked and germinated, and almost in every case there was a rupture of the hypocotyl; not a total break, but quite sufficient to bring about a slowing down of food transference. It is not suggested that these experiments are conclusive by any means, since abnormal conditions were set up by the removal of the coat as well as the band. The ideal procedure would be to remove the band without touching the overlying coat, but this is obviously impossible.

To sum up, the function of the combined structure is either to act as a food-transferring mechanism or to hold the radicle in position during the early stages of germination, thus preventing a rupture of the tissues of the hypocotyl, due to the backward pressure exerted by the radicle in its endeavour to break through the mechanical barrier formed by the seed-coat.

It seems not improbable that similar bands may be discovered on the seed-coats of other members of the Leguminosæ, and their investigation may be the means of throwing additional light on the function of these structures. In the meantime, when further stages of the maturation of the broad bean have been studied, it is hoped to give a full account of the development of the bands, and to confirm their function.

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EXPLANATION OF PLATE.

Illustrating Dr. Orr's paper on *Vicia Faba* L.

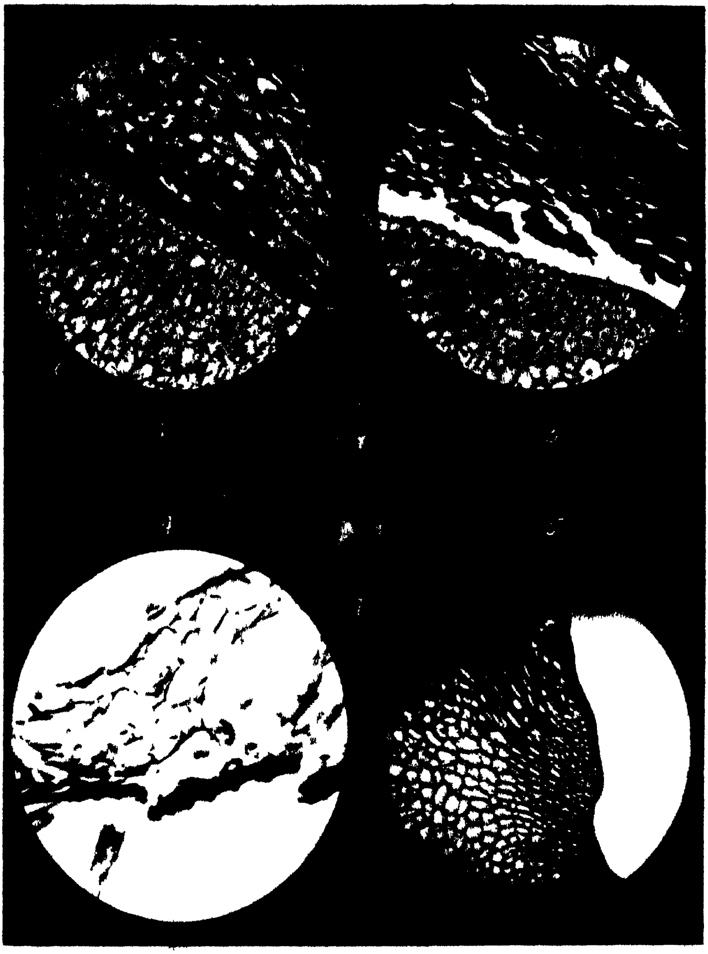
Fig. 1. Part of the testa of the seed of *Vicia Faba*, seen from the inside, showing the crescent-shaped areas to left and right of the radicle pocket.

Fig. 2. T.S. of seed through a crescent-shaped band: *a*, nutrient layer; *b*, crescent-shaped band; *c*, hypocotyl and cotyledon. ×45.

Fig. 3. The same with the cotyledon and hypocotyl separated from the band: *a*, papillate surface of the hypocotyl; *b*, smooth surface of cotyledon. ×45.

Fig. 4. A portion of a crescent-shaped band in section showing the serrated surface. ×200.

Fig. 5. T.S. of cotyledon and hypocotyl, showing the orientation of the elongated cells extending from the "clamp connection." ×45.



H. R. Orr.

The Anatomy of Potamogeton pectinatus.

By G. K. Graham Campbell, B.Sc.

(Read 11th June 1936.)

In the course of dredging for material in Cameron Reservoir in the autumn of 1935 some moribund specimens of *Potamogeton pectinatus* L. were collected. The chief point of interest in these plants was the turio, or winter-resting organ. It was decided to investigate anatomically those parts of the plant available. The species has been fully described, but it seems advisable to give a brief account of the method of branching and of the turio. The material consisted of detached vegetative shoots about 45 cm. in length, made up of filiform stems. The leaves are borne singly at the nodes, and each is made up of a sheathing base, a ligule, and a filiform lamina.

In the axil of the older leaf is a branch; using the terminology of Hagström (1), this is designated the sterile shoot. One or two branches are borne on this shoot very close to the main stem node; the first of these, the fertile branch, repeats the behaviour of the main stem, and where the second is present it bears the turio branch. After this ramification the sterile shoot ends vegetatively in 2–4 leaves (fig. 1). The turio consists of a stalk, a swollen storage region which usually branches, and a narrower tip protecting the stem apex (fig. 1).

The Adult Main Stem (fig. 2).

The stele is centrally disposed; in the middle is a lacuna merging at the node into elongated cells with spiral lignified thickening. The remainder of the stele is of more or less undifferentiated phloem, elongated parenchyma cells. Surrounding the stele is the endodermis, a sheath one cell thick; the cells are lignified and heavily thickened on the radial and inner tangential walls, which are pitted. In the cortex may be distinguished three regions, an inner region where the

intercellular spaces are small, an outer zone traversed by air lacunae, and a hypodermis one cell thick. Between the outer and inner zones of the cortex are the small fibro-vascular bundles; normally there are two or three of these arranged in two diametrically opposite groups. Each bundle consists of a few small elongated cells surrounded by a sheath of

FIG. 1.—*Potamogeton pectinatus.* General aspect. 1, main axis; 2, fertile branch; 3, sterile branch; 4, turio branch; 5, leaf.

thickened and lignified cells. The stem is bounded by the epidermis, which is lightly cuticularised and is without stomata.

THE LEAF.

The leaf consists of a sheathing base 10 mm. long, the thickness at the mid-rib increasing towards the point of detachment of the lamina and the ligule. The ligule is small and membranous; the lamina is circular in section and averages 25 mm. in length. There are no stomata. At the node a trace passes from the central stele into the leaf base,

with a lateral bundle on either side derived from the crescents in the cortex (see p. 182); as the base thickens, an air lacuna appears on each side of the central bundle or mid-rib. Approaching the disjunction of leaf and lamina, the lateral bundles fork; the inner branches pass with the mid-rib and lacunae up into the lamina, while the outer branches pass into the ligule. As in the stem, the large air lacunae must

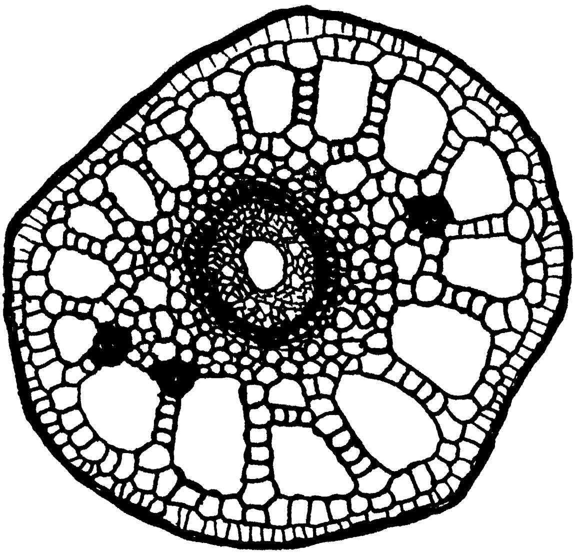


FIG. 2.—*Potamogeton pectinatus.* Transverse section of adult stem.

serve the dual purpose of affording buoyancy and a reservoir for the gases involved in the vital processes of respiration and photosynthesis; this would in part overcome the low oxygen content of the water.

APICAL BUDS.

The apical bud in an aquatic is usually a much elongated cone, with the leaf primordia well developed to the end of the cone. In *Potamogeton pectinatus* the apical cone is much shorter and in some cases definitely flattened (fig. 3). This was the case for both the vegetative axes and the tips of the turios.

NODAL ANATOMY (fig. 4).

At a typical node the leaf subtends a short sterile shoot whose first internodes are short. At the first node of this shoot the fertile branch arises towards the main axis; at the second, the turio branch arises on the opposite side (but in the younger parts of the plant it may be only an undeveloped bud). These branches all lie in one plane, which, for convenience, may be referred to as the plane of branching. Within the stem at the node it is found that the cortical

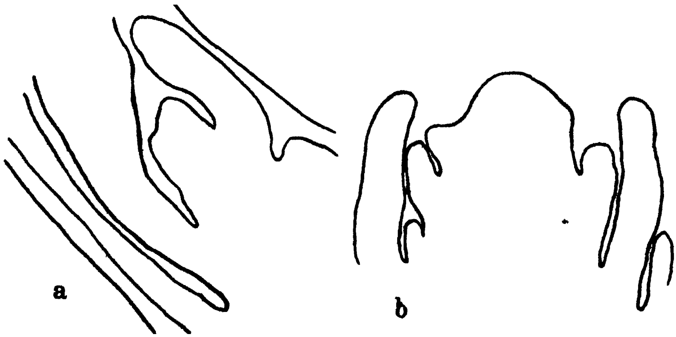


FIG. 3.—*Potamogeton pectinatus* Longitudinal section of stem apex, *a*, conical type, *b*, flattened type.

bundles are perpendicular to the plane of branching, and as they approach the node from below they merge into crescents from each of which is given off a small strand linking with the central stele. The leaf is supplied by a trace from the central stele, supplemented by a small strand from each of the crescents in the cortex.

The central cylinder broadens in the plane of branching and bifurcates; one part passes into the main stem (accompanied by cortical bundles derived from the crescents), the other enters the sterile branch. While this forking is taking place the branch bundle gives off two narrow crescents, diametrically opposite each other and at right angles to the plane of branching, and each divides to give two or three small cortical bundles.

At the level where the sterile branch leaves the main axis the latter has a central bundle and two cortical, these being derived from the crescents; the sterile branch has a central

and from four to six small bundles, these latter arranged in two diametrically opposite groups. The stele in the sterile branch now sends out a small trace to the reduced leaf subtending the turio branch and then bifurcates; the abaxial branch of the stele continues in the sterile shoot, and the

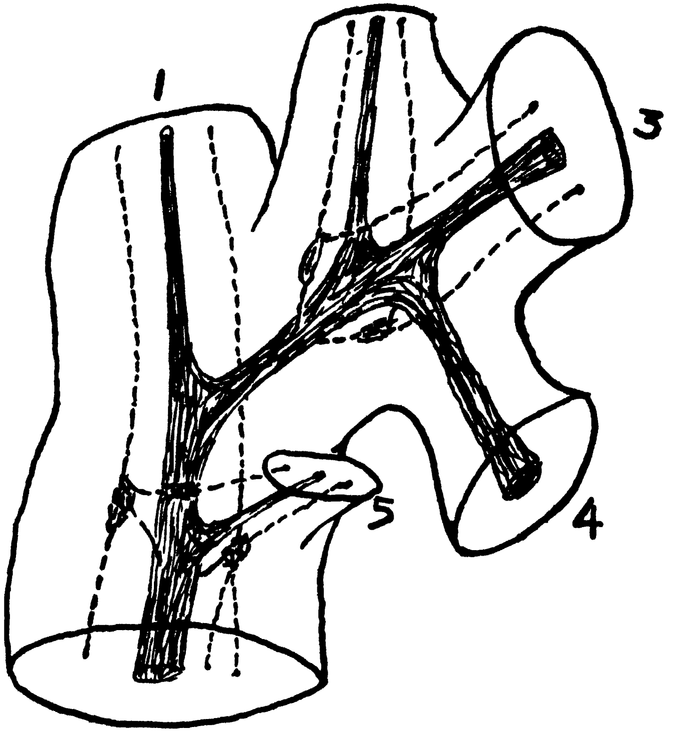


FIG. 4.—*Potamogeton pectinatus.* Nodal anatomy; diagram from serial sections, to show the course of the vascular strands through the nodes. 1–5 as in fig. 1.

adaxial supplies the fertile shoot. As these steles separate, the adaxial pair of cortical bundles pass up into the cortex of the fertile branch; on each side of the sterile branch stele the other bundles fuse to give an opposite pair, which remain in the cortex of the sterile shoot. The sterile and fertile branches then separate. The sterile branch stele again forks, the abaxial part passing into the turio branch; the other continues in the sterile branch.

The central stelar lacuna is continued through the node in

main stem only; in the other nodes its place is taken by elongated cells with cellulose walls and simple spiral thickening which is lignified. The lacunae reappear in the branches as these separate, except in the turio branch, whose stele, in the mature condition, consists of lignified cells.

The Turio (fig. 1).

The turio has already been mentioned as a structure of especial interest; it consists of a stalk, a storage region (which usually bears a similar branch), and a tip enclosing the apical bud. The stalk differs from the main stem in having an undifferentiated cortex without fibro-vascular bundles, and in having the endodermis lignified but unthickened; also the stelar elements are lignified and there is no central lacuna. This altered construction must facilitate the detachment of the turio during the autumn, as the lignified tissue would fracture easily.

The storage region averages 6 mm. in length by 1 mm. in diameter. It differs from the other axes in having a uniform closely packed cortex whose function is the storage of reserves, the endodermis is in the primary condition, unthickened, and one or two of the central cells of the stele have the spiral lignified thickening found at the normal nodes. The cortex forms the bulk of the tissue of the storage region; it consists of large cells packed with starch grains, and with only very small intercellular spaces.

The apical bud of the turio is borne on a stem 3 mm. from the end of the storage region. At the node which terminates that part there is a sheathing leaf 6 mm. long completely enclosing the end of the stem, whose apex is further protected by the development of two or three short leaves which remain within the sheath in the winter.

The turios are separated from the parent plant in the autumn, and at that season it is often possible to find them in large numbers washed up on the shores of the loch, where they are mixed with a profusion of fruits of various species of *Potamogeton*; this would confirm the opinion that they function not only for perennation but also for dispersal.

Germination begins with the increasing temperature in the spring, and although it was impossible to collect any specimens

from the loch at that season, the course of events was observed in turios germinated artificially in the laboratory. The first sign of germination is the rupture of the sheathing leaf at its tip by an acute leaf, which turns to grow up towards the light; this is soon followed by other leaves. Simultaneously adventitious roots are produced, first at the end of the storage region, then at the bases of the leaves at the apex of the young stem.

Discussion.

The marked departure from the normal layout of the tissues, as found in the land plant, may be interpreted by reference to mechanical and physiological considerations; and occasionally comments on these grounds have been made in the foregoing description.

The stems are slender, and movements of the water will set up considerable tensile strains; these are countered by the central disposition of the vascular tissue and the thickening of the lignified endodermis. The absence of xylem, as also the large intercellular spaces, must be referred to the aquatic environment, which results in a deficiency of oxygen and an abundance of water.

It seems probable that the small cortical bundles have as their function the prevention of excessive torsion of each internode, for their small size in comparison with the central stele must render their conducting function equally insignificant.

In the internode the stele is simple; there is the central lacuna surrounded by phloem differentiated only to a small degree. At the node and in the turio the centre of the stele is occupied by elongated cells with spiral thickening which is lignified; there is no indication of a pith. The nodal anatomy is in accordance with the fact that the earliest development of the wood is, as a general rule, at the node; while the absence of wood in the internodes indicates that the central cavity must be regarded as a xylem lacuna, arising as a result of the easy access of water to each cell.

Summary.

1. The histology of the adult main stem and leaf is described.
2. The method of ramification is described.
3. The structure and histology of the turio are described.
4. Changes in the endodermis and stele are discussed.

Reference.

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An Investigation of the Latex Systems in Euphorbia marginata, with Particular Attention to the Distribution of Latex in the Embryo. By Donald Cameron, B.Sc. (With Pl. III.)

(Read 11th June 1936.)

In the course of the past few years a good deal of work has been done on latex-producing plants, as a result of which three types of latex system have been recognised. The one with which we are concerned here is known as the non-articulated branched type, and consists of a number of tubes, present in both the adult plant and the embryo, which run vertically in the internodes and branch in the nodes.

The Embryo.

The distribution of the latex systems in the embryo (fig. 1) can be described as follows: There are two series of latex tubes in the embryo, an inner and an outer, both of which run in the direction of the main axis. That nearer the centre consists of wide tubes which lie alongside the vascular bundles in the hypocotyl and root. These wide tubes comprise the stelar latex system (S.L.) and send out horizontal branches (*h*) in the region of the cotyledonary node. These are shown in section in the diagram, but form a pair of arches which diverge from a common base and surround the young conducting tissue of the stem apex.

Above the node the stelar latex tubes continue to accompany the vascular bundles, but they send out numerous branches into the mesophyll of the cotyledons.

The outer series consists of much narrower tubes, and occurs in the cortex. This is the cortical latex system (C.L.), and it is also unbranched in the hypocotyl and root. The tubes branch profusely on passing into the cotyledons, and along with the branches from the stelar latex system form an open network of tubes in the mesophyll.

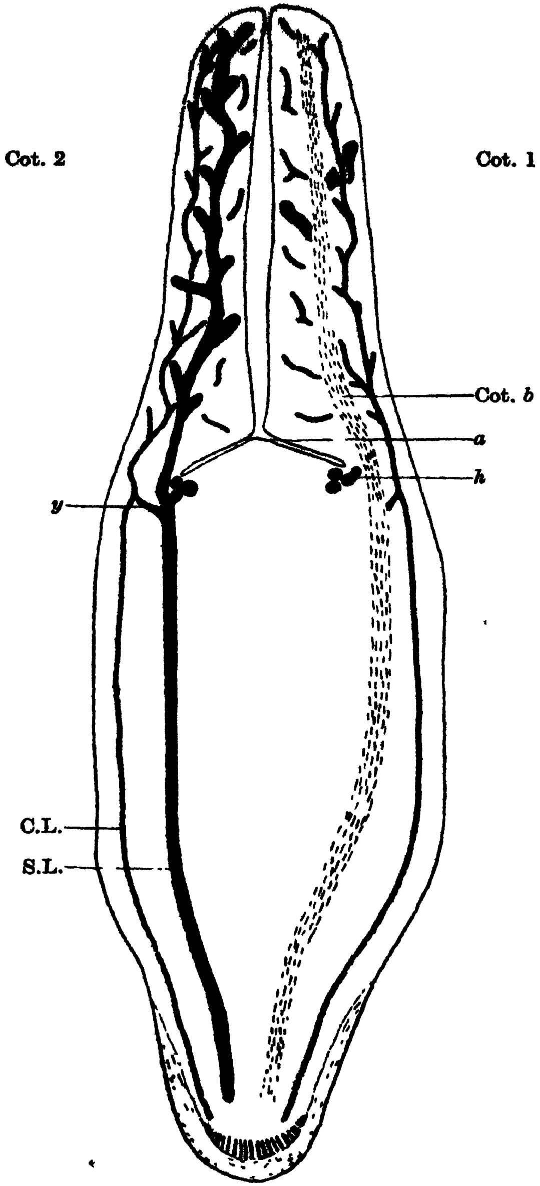

FIG. 1.—Diagram of the embryo of *Euphorbia marginata* to show the distribution of the latex systems.

C.L. Cortical latex system of the hypocotyl.
S.L. Stelar latex system of the hypocotyl.
h. Horizontal latex tubes in the cotyledonary node.
y. Yoke between stelar and cortical latex systems.
a. Stem apex of the plumule.
Cot. *b*. Vascular bundle of the cotyledon.
Cot. 1 and Cot. 2. Cotyledons.

The stelar and cortical latex systems are connected in the region of the cotyledonary node. A branch (*y*) passing outwards from one of the stelar latex tubes joins one of the cortical tubes immediately below the epidermis. This was observed in two cases only in transverse section (fig. 2).

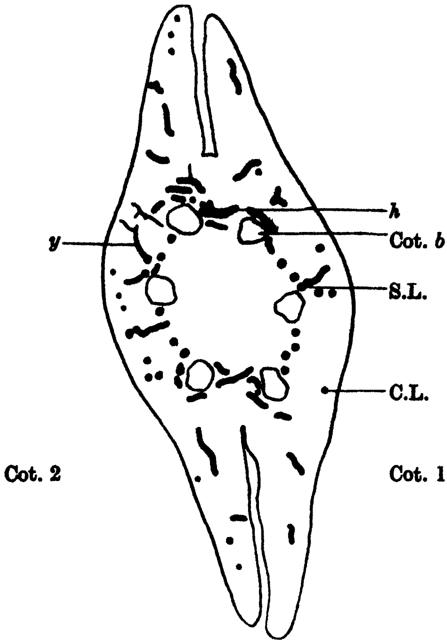

FIG. 2.—T.S of the embryo through the cotyledonary node to show the connection between the cortical and stelar latex systems (Camera lucida drawing. × 55)
C.L. Cortical latex tube.
S.L. Stelar latex tube.
h. Horizontal latex tubes of the cotyledonary node.
y. Yoke between stelar and cortical latex systems.
Cot. *b*. Cotyledonary vascular bundle.
Cot. 1 and Cot. 2. Cotyledons.

Anastomosis was observed also in one instance in a longitudinal section at right angles to the plane of insertion of the cotyledons (Pl. III, A). Branches were given off in the node by two parallel tubes, and where the branches came into contact, one with the other, anastomosis occurred.

A transverse section through the hypocotyl region of the embryo is circular. Taken in order from the exterior, the

tissues are: an epidermis, a cortex about eight cells deep, and a central cylinder consisting of six strands of vascular tissue surrounding a pith. The cortical and stelar latex systems are distinct in this region (fig. 3). The cortical system (C.L.) appears as a number of isolated cells occurring up to a depth of about five cells below the epidermis. They are absent from the three remaining cell-layers of the inner cortex. The stelar latex system (S.L.) consists of a number of fairly large cells, two or three of which are present on either side of each

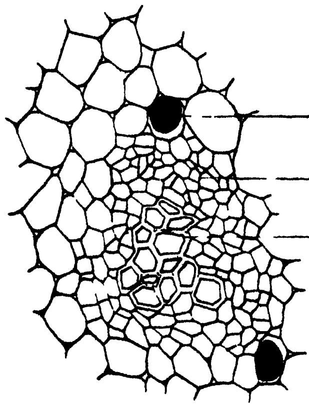

FIG. 3.—T.S. of embryo through the hypocotyl. (Camera lucida drawing. ×55.)
C.L. Cortical latex tubes.
S.L. Stelar latex tubes.
v.b. Vascular bundle of the hypocotyl.

vascular bundle (*v.b.*). The bundles in the embryo are not differentiated into xylem and phloem.

On descending into the root, the latex systems in the collet region show little change in their relative positions. Below this the root tapers off and has a narrower cortex. This brings the two systems closer together, but they remain distinct, as an endodermis is becoming differentiated immediately outside the stelar latex system. The root-cap is distinct at this point.

Both latex systems end blindly in the root, but the cortical system extends beyond the stelar system, though neither is present in the apex.

In ascending the hypocotyl the behaviour of the latex

systems in the region of the cotyledonary node (fig. 1) immediately attract attention.

The cortical latex tubes of the hypocotyl pass undisturbed through the node into the cotyledons. The stelar tubes, on the other hand, give off a number of horizontal branches (*h*) on reaching that region. These branches form a ring of tubes in close proximity to one another. This branching begins in the portion of the hypocotyl in which the orientation of the cotyledons first becomes apparent. The lateral bundles of the cotyledons can now be distinguished, and the first of these latex branches occurs between the pairs of lateral bundles. As the expansion of the cotyledons proceeds (Pl. III, B), the latex tubes which accompany the central bundles of the cotyledons branch. Thus the horizontal branches of the stelar latex system form an arch within the base of each cotyledon. These arches reach their summits in the cotyledons just below the level of the stem apex of the plumule (fig. 1, *a*).

Longitudinal sections at right angles to the plane of insertion of the cotyledons show this arch formation clearly.

The horizontal latex tubes in the nodal region surround the vascular tissue of the stem apex, but are within the vascular ring of the hypocotyl (Pl. III, B).

Passing farther into the cotyledons, the latex tubes branch profusely. The stelar latex tubes continue alongside the cotyledonary bundles and send out numerous branches into the mesophyll. The cortical latex system, however, is the more branched in this region.

The Seedling.

Transverse sections through the cotyledonary node of the young seedling show that the latex tubes are distributed in the same two systems as in the embryo.

The six primary vascular bundles are visible in the nodal region, and leave the central cylinder as the cotyledonary bundles. Another six bundles appear between these and form the vascular tissue of the young stem.

The stelar latex system, which sends out horizontal branches to surround the vascular tissue of the stem, is reorganised above the node. Some of the tubes take up a position along-

side the phloem of the cotyledonary bundles (fig. 4), while others are ranged alongside the stem bundles. The cortical tubes are unbranched in the node and pass out into the cotyledons. The latex tubes of the young stem are apparently all derived from the stelar latex system of the hypocotyl.

Ascending the stem to where the first two leaves begin to come off, the central leaf-trace bundle is distinct from the rest of the vascular tissue and is accompanied by latex

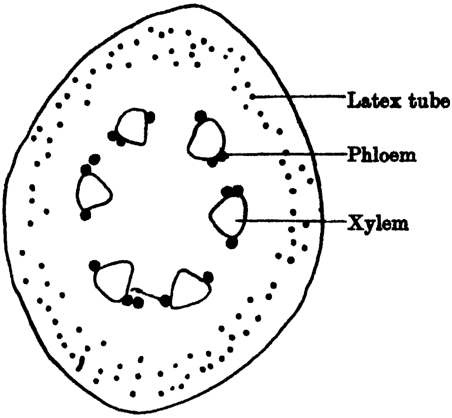

FIG. 4.—Vascular bundle from T.S. Cotyledon of 2-in. seedling, to show the latex tubes alongside the phloem. (Camera lucida drawing. ×250.)

tubes. A number of horizontal tubes are visible where the margins of the leaves are not yet free from the stem.

Ascending through a stem node of an advanced seedling, conditions different from those in the embryo and young seedling are observed. There is a ring of vascular bundles in the stem, at various stages of development and separated from one another by medullary rays. The three largest bundles form the trace of the leaf above. There are one or two latex tubes on either side of the phloem of these bundles. The latex tubes branch at a point where the departure of the bundles from the central cylinder is complete. One branch returns to the stem, where it takes up a position alongside the bundle replacing the departing trace. The other continues into the leaf.

The branches do not completely surround the vascular tissue of the stem node, but only run horizontally for a short distance.

A. B.

Euphorbia marginata

A. L.S. of the embryo to show anastomosis between two parallel latex tubes in the region of the cotyledonary node (×200.)

B. T.S. of the upper part of the region of the cotyledonary node to show the girdle of horizontal branches formed by the stelar latex system. (×40.)

DONALD CAMERON.

Summary.

The latex tubes in *Euphorbia marginata* are of the non-articulated branched type and form two distinct systems in the plant.

The cortical latex system is found in the cortex of the hypocotyl and consists of narrow tubes which branch on entering the cotyledons. This system has not been observed, in the material available, to make any contribution to the latex system of the stem.

The stelar latex system occurs alongside the phloem of the vascular bundles in the hypocotyl and consists of much wider tubes. These pass through the cotyledonary node into the cotyledons, but before doing so they give rise to a ring of horizontal tubes which surround the vascular tissue of the stem. The latex system of the stem grows up from this ring.

Anastomosis was observed in one instance in the embryo, but does not appear to be of general occurrence, as the horizontal tubes in the region of the cotyledonary node are often in close contact but remain distinct. D. H. Scott and J. Schullerus have recorded that anastomosis is absent from those species with non-articulated latex systems on which they worked.

In the two cases in which a connection was observed between the stelar and cortical latex systems in the nodal region of the embryo anastomosis also appeared to occur.

The vascular bundles in the young stem are accompanied by latex tubes, which give off horizontal branches in the nodal regions. The departure of the leaf-trace is gradual and the leaves are spirally arranged, with the exception of the first and second, which are opposite. This affects the appearance of the latex system in the stem nodes. The horizontal branches in the case of the opposite leaves more completely surround the vascular cylinder than in the case where the leaves are alternate.

The distribution of the latex system in the seedlings of *Euphorbia marginata* corresponds closely to the distribution in the embryo. This work was undertaken as a research exercise for Honours, and the writer wishes to acknowledge his indebtedness to Mr. R. A. Taylor of the Botany

Department of University College, Dundee, who suggested the problem and who has been in constant touch with it throughout.

REFERENCES.

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SCOTT, D. H.: On the Laticiferous Tissue of *Manihot Glaziovii*. Quart. Journ. Micro. Sci., new ser., xxiv (1884), 194–204.

THE CENTENARY MEETING.

The Centenary of the Society was celebrated on 1st July 1936 at the Royal Botanic Garden. At a meeting at 10 a.m. delegates from other Societies and Institutions were received by the President, Professor Sir WILLIAM WRIGHT SMITH.

The delegates who were able to attend were:—

	Representing
Professor Sir A. C. SEWARD .	The Royal Society, also University of Cambridge, and The Academy of Natural Sciences of Philadelphia.
Principal CHARNOCK BRADLEY .	Royal Society of Edinburgh.
Professor H. H. DIXON . .	Royal Dublin Society.
Professor N. E. SVEDELIUS .	Royal Swedish Academy of Science, also The Royal Society of Sciences of Uppsala, The Swedish Botanical Society, Botanical Institute of Uppsala.
Mr. J. RAMSBOTTOM . .	The Linnean Society of London, also British Museum (Natural History), The Essex Field Club, The Quekett Microscopical Club.
Lord ABERCONWAY . . .	Royal Horticultural Society.
Mr. W. WILLIAMSON . .	Royal Microscopical Society.
Dr. H. HAMSHAW THOMAS .	Cambridge Philosophical Society.
Professor T. E. HAZEN . .	Torrey Botanical Club, and The New York Botanical Garden.
Dr. WESLEY G. HUTCHINSON .	American Philosophical Society, and University of Pennsylvania.
Miss E. VACHELL . . .	Cardiff Naturalists' Society.
Dr. JAMES KNIGHT . . .	Royal Philosophical Society of Glasgow.
Mr. JOHN R. LEE . . .	Glasgow and Andersonian Natural History and Microscopical Society.
Mr. J. H. ALEXANDER . .	Royal Scottish Forestry Society.
Miss ELLA CHRISTIE . .	Royal Scottish Geographical Society.
Mr. CHARLES J. COUSLAND .	Royal Scottish Society of Arts.
Mr. J. A. WATSON . . .	Edinburgh Geological Society.
Mr. GEORGE W. HARE . .	Edinburgh Natural History Society.
Mr. MAURICE G. KIDD . .	Royal Caledonian Horticultural Society.

Mr. William Robb . . .	Scottish Society for Research in Plant Breeding.
Mr. A. D. Buchanan Smith .	Iowa State College of Agriculture and Mechanic Arts.
Professor E. E. Cheesman .	Imperial College of Tropical Agriculture.
Mr. P. R. Laird . . .	Department of Agriculture for Scotland.
Mr. J. A. B. Macdonald . .	Forestry Commission (Scotland).
Dr. E. Wyllie Fenton . .	Edinburgh and East of Scotland College of Agriculture.
Dr. David Clouston . .	The North of Scotland College of Agriculture.
Mr. W. F. Burnett . .	The West of Scotland Agricultural College.
Sir A. W. Hill . . .	Royal Botanic Gardens, Kew.
Dr. J. Burtt Davy . .	University of Oxford.
Professor J. R. Matthews .	University of London, also University of Aberdeen.
Professor R. J. D. Graham .	University of St. Andrews.
Professor J. Walton . .	University of Glasgow.
Professor Sir T. Hudson Beare	University of Edinburgh.

It was intimated that the following delegates had been appointed but had been prevented from attending:—

	Representing
Professor G. W. Scarth . .	The Royal Society of Canada, also McGill University.
Sir David Prain . . .	Société Botanique de France.
The Portuguese Ambassador .	Academy of Sciences of Lisbon.
Mrs. Sandwith . . .	Bristol Naturalists Society.
Mr. R. B. Cooke . . .	Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne.
Professor J. H. Priestley .	The University, Leeds.
Professor J. McLean Thompson	The University of Liverpool.
Mr. Roger C. Smith . .	Kansas Academy of Science.

The following Societies and Institutions, though unable to send delegates, sent their congratulations and good wishes for the future:—

Société Botanique de Bulgarie.
Dansk Botanisk Forening.
Societas pro Fauna et Flora Fennica.
Society of Forestry in Suomi.
Botanischer Verein der Provinz Brandenburg.
Schlesische Gesellschaft für vaterländische Cultur.

Senckenbergische Naturforschende Gesellschaft.
Nederlandsche Botanische Vereeniging.
Société Botanique de Pologne.
Polska Akademja Umiejetnosci.
Société des Naturalistes Luxembourgeois.
Naturforschende Gesellschaft in Bern.
Schweizerische Naturforschende Gesellschaft.
Botanical Society of Geneva.
Botanical Institute of the U.S.S.R. Academy of Sciences.
Rochester Academy of Science.
Hertfordshire Natural History Society and Field Club.
Statens Plantepatologiske Forsøg, Lyngby.
Bureau of Plant Industry, U.S. Department of Agriculture.
Botanic Garden, Oslo.
Arnold Arboretum.
Missouri Botanical Garden.
Université de Liège.
Faculté des Sciences de Marseille.
Charles University, Prague.
Rijksuniversiteit te Utrecht.
Landbouwhoogeschool, Wageningen.
Institute of General Botany and Institute of Systematic Botany, University of Geneva.
Central Asiatic State University.
Universitetet i Lund.
Cornell University.
University of Minnesota.
University of Missouri.
Syracuse University.
University of Durham.

After speeches had been made by delegates and congratulatory addresses presented (see p. 200), Professor F. O. Bower, senior surviving President of the Society, gave an address (see p. 209). On the motion of Mr. J. Rutherford Hill a very very hearty vote of thanks was accorded to Professor Bower.

After being photographed on the lawn, the company was taken by special motors to the Old College. The Upper Library Hall had been kindly lent by the University Court to the Society for the occasion, and here lunch was served

to a company of about 150. At the lunch Lord ABERCONWAY proposed the toast of the City of Edinburgh, which was replied to by Lord Provost GUMLEY. The toast of the Society was proposed by Professor Sir A. C. SEWARD and replied to by the President, Sir WILLIAM WRIGHT SMITH. The toast of the Guests was proposed by Dr. MALCOLM WILSON, and on their behalf Sir A. W. HILL replied.

In the afternoon members and guests returned to the Royal Botanic Garden, and the company then divided into parties which were shown round the Garden. Later tea was served in the large laboratory, where an exhibition, which also occupied another room, had been laid out. The main items of interest in the exhibition were as follows:—

The first Minute Book of the Botanical Society, showing the names of the 21 original members of the Society.

Portraits of most of the Presidents of the Society.

Greville's own copy of the section Cryptogamia of "Flora Edinenses," with MS. additions by himself; also a number of his original drawings of plant scenery.

A number of paintings of medicinal plants by Mrs. Hutton Balfour.

The Minute Book of the Scottish Alpine Botanical Club, with the Club Snuff Mull and Club Song; also a large number of photos of localities visited by the Club, with lists of the notable plants collected at each place.

A number of living plants and of dried specimens of plants named in honour of prominent members of the Society.

Herbarium sheets of George Forrest's most outstanding horticultural introductions, especially of the genera *Primula*, *Rhododendron*, *Nomocharis*, and *Gentiana*.

A number of Herbarium specimens of rare British Mosses and Lichens, also specimen pages of G. H. Traill's books of Sea Weeds.

The Scottish Plant Breeding Station presented an exhibit designed to illustrate the scope and some of the uses of Experimental Taxonomy. It was emphasised that experimental taxonomy involves the study not only of morphology and phytogeography, but also of ecology, genetics, cytology, etc., and that it is envisaged as the classification of evolutionary groups strictly as they occur in Nature. Photographs and diagrams illustrated a proposed genecological classification

of the Linnean species *Phleum pratense* and *alpinum*, and of the Coronopus section of the genus *Plantago*.

The Plant Pathological Service of the Department of Agriculture for Scotland presented the following exhibits : (1) Bracken Disease (*Corticium anceps* (Bres. et Syd.) Gregor). Photographs and herbarium specimens showing the appearance of the disease and a series of new fern hosts (see Gregor, M. J. F.: Phytopath. Zeitschr., viii (1935), 401–419). (2) Tomato Toe Root (*Phytophthora* sp.). Diseased plants and photographs of the causal fungus which is new to science (see Howells, D. V.: Scot. Jour. Agric., xix (1936), 47–49). (3) Storage Rot of Potato (a fungus in *Phomaceae*). Diseased tubers, inoculated tubers, and photographs of disease and causal fungus. This is a new explanation of much of the rots of potato in storage (see Alcock, N. L., and Foister, C. E.: Scot. Jour. Agric., xix (1936), 252–257).

In the evening the Magistrates and Town Council of the City of Edinburgh honoured the members and delegates and friends by a Reception in the City Chambers. Lord Provost Gumley received the guests and again congratulated the Society on its Centenary.

ADDRESSES TO THE SOCIETY ON THE OCCASION OF ITS CENTENARY.

Address of Congratulation and Good Wishes from the Royal Society of London to the Botanical Society of Edinburgh.

The Royal Society of London sends greetings and cordial congratulations to the Botanical Society of Edinburgh on the celebration of one hundred years of active participation in the promotion of natural knowledge.

Since the latter part of the seventeenth century Edinburgh has been one of the great centres of learning in the western world, and the foundation of the Botanical Society in 1836 was a consequence of the ramification of research along different lines of enquiry.

The Royal Society looks forward with confident hope to the continued progress of a Society which has earned the gratitude of many workers in the botanical field.

Signed on behalf of the President, Council, and Fellows of the Royal Society of London,

W. H. Bragg, *President.*

Societati Botanicae Edinburgensi s.p.d. Societas Regia Scientiarum Upsaliensis.

Gratae nobis fuere litterae vestrae, quibus nos benigne invitastis, ut e coetu nostro socium eligeremus, qui vobiscum sollemnibus saecularibus societatis vestrae interesset. Perlibenter huic invitationi obsecuti sumus.

Meminisse nos iuvat, Carolum illum Linnaeum, quem vos quoque ducem sequimini, unum e nostris fuisse, nec minus iuvat ex vestris actis scriptisque cognovisse, quantum ad res naturales investigandas botanici edinburgenses ingenio atque industria contulerint.

Persuasum quaesumus habeatis, nos ex animi sententia

prosperis rebus vestris laetari vobisque faustum alterum saeculum precari. Vigeat, crescat, floreat Societas Botanica Edinburgensis.

DABAMUS UPSALIAE M. MAIO A. MCMXXXVI.

GUSTAF GÖTHLIN, *Praeses.*
ÖSTEN BERGSTRAND, *Secretarius.*

SOCIETATI BOTANICAE EDINBURGENSI. S.P.D.
INSTITUTIO BOTANICA UNIVERSITATIS REGIAE UPSALIENSIS.

Vobis, memoriam saecularem Societatis Vestrae festis diebus sollemniter celebraturis, nos botanici Upsalienses non possumus non gratulari, quod ad progressus incrementaque scientiae nostrae amabilis per hos centum annos opera atque ingenio tantum contulit Societas Vestra. Quam felicitatem prosperitatemque ut futura saecula Vobis servent et in maius semper augeant, ex animi sententia precamur.

NILS E. SVEDELIUS,
Institutionis Botanicae
Universitatis Regiae Upsaliensis Praefectus.

DABAMUS UPSALIAE
M. MAIO A. MCMXXXVI.

THE LINNEAN SOCIETY OF LONDON

in conveying its hearty congratulations to the Botanical Society of Edinburgh on the completion of the hundredth year of its activity, desires to express its appreciation of the results achieved by a body of workers whose labours, recorded in the thirty-one volumes of the "Transactions and Proceedings," have greatly enriched the common stock of natural knowledge. When The Linnean Society of London was founded special stress was laid on the natural history of Great Britain and Ireland, and the Society, in congratulating the Botanical Society of Edinburgh on its long and active life, remembers in particular the valuable additions which it has made to our knowledge of the distribution of Scottish plants.

That the Botanical Society of Edinburgh may flourish in

the future, as it has flourished in the past, is the sincere desire of those whose names are underwritten on behalf of The Linnean Society of London.

Given under the Common Seal of the Society this fourth day of June in the year one thousand nine hundred and thirty-six.

W. T. CALMAN, *President.*
J. RAMSBOTTOM }
STANLEY KEMP } *Secretaries.*

ROYAL MICROSCOPICAL SOCIETY,
B.M.A. HOUSE, TAVISTOCK SQUARE,
LONDON, *July* 1, 1936.

The President, Council and Fellows of the Royal Microscopical Society send cordial greetings and hearty congratulations to the President and Members of the Botanical Society of Edinburgh upon the celebration of their Centenary Meeting and wish the Society a happy and prosperous continuance of its long and honoured history.

Signed on behalf of The Royal Microscopical Society,

R. TANNER HEWLETT, *Honorary Secretary.*

Quo die Societas Botanica Edinburgensis sacra sua natalicia post annos centum feliciter recurrentia solemniter celebrat, Societas Polonorum Botanica singularium meritorum memor, quae tot eius socii praeeunte I. B. Balfour, in scientiae botanicae progressum maximeque in Scotiae plantas penitus pernoscendas contulerunt, fraternam ei gratulationem mittit adiuncto voto, ut novum quod ei hodie illuxit saeculum non minore cum successu peragat.

ZYGMUNT WÓYCICKI, *Praeses Societatis.*
BOLESLAW HRYNIEWIECKI, *Wice-Praeses.*
SEWERYN DZIUBALTOWSKI, *Secretarius.*

The document also has the above address in Polish.

To the President of the Botanic Society of Edinburgh.

Sir,—The hundredth anniversary of the foundation of the Botanic Society of Edinburgh is a great day not only for that Society, but for all science, and it will find a joyful echo in all centres of scientific research throughout the world. The labours of scientific investigation, conducted by several generations of eminent men of learning, who were members of the Society, are among the most glorious chapters in the history of botany, and have contributed in very great measure to raising that science—so important for general civilisation—to the high position which it now occupies.

The Polish Academy of Sciences and Letters feels happy in having the opportunity, on this solemn day, to do homage to the memory of the illustrious figures of the Society and of its numerous distinguished members, as well as to offer its best wishes to the Society for the future. May the Society, whose annals during the first century of its existence have been so full of great achievements, go on from greater to greater glories in many a following century, for the good of learning and for the happiness of mankind.

Stanislav Wróblevski, *President*,
Stanislav Kutrzeba, *Secretary*,
of the Polish Academy of Sciences and Letters.

Kraków (Cracow), Poland,
June 20, 1936.

To the President and Members of the Botanical Society of Edinburgh.

Sirs,—The Institute for General Botany as well as the Institute for Systematic Botany of our University, to the latter of which the Herbier Boissier, the Botanical Conservatory and Garden are now attached, and the Botanical Society of Geneva, wish to thank you very much for the invitations of the Botanical Society of Edinburgh to its Centenary.

Unhappily, it will not be possible to send delegates to Edinburgh for the first of July, but the above-mentioned institutions unite in sending to you their congratulations and

their best wishes for the continuation of the remarkable scientific activity of your Society.

We cannot but remember that your City is famous from a botanical point of view on account of its distinguished botanists, for instance Robert Graham, John Hutton Balfour and Sir Isaac Bayley Balfour, also Alexander Dickson, to whom we wish to add the name of the actual celebrated Keeper of the Garden and Museum, Sir W. Wright Smith, not forgetting the older ones as James Sutherland, Charles Alston, John Hope, and others.

We are proud to have in our library the complete set of your "Transactions" as well as the "Notes" from your Botanic Garden, which contain so many important papers indispensable to every botanist.

Such a record makes your city one of the principal centers for botanical science and, Geneva being also attached to this activity, it is natural that it should feel itself in thought with you at the celebration of your first century.

Prof. F. Chodat,
The Director of the Institute for General Botany of the University.

B. P. G. Hochreutiner,
The Director of the Institute for Systematic Botany of the University.

Edouard Thommen,
The Chairman of the Botanical Society of Geneva.

Genève, *le* 23 *mai* 1936.

Edinburgh and East of Scotland College of Agriculture.

13 George Square,
Edinburgh, *June* 30, 1936.

On behalf of the Board of Governors and members of staff of the Edinburgh and East of Scotland College of Agriculture I have charged Dr. Fenton, the head of our Botany Department, to convey to the Executive and members of the

Edinburgh Botanical Society our very cordial greetings and congratulations on the memorable event of the Centenary of the Society. Embracing within its membership not only professional botanists but members of the general community who are primarily attracted to botanical study by an inherent interest in and love for the Plant Kingdom, the Society has carried on throughout these years work possessed of a high degree of scientific, cultural and recreational value, and it is our sincere wish that it may long continue to flourish.

E. SHEARER, *Principal.*

BRITISH MUSEUM (NATURAL HISTORY).

The Trustees of the British Museum convey their most cordial congratulations to the Botanical Society of Edinburgh on the attainment of its Centenary.

As the Custodians of the National Botanical Collections the Trustees sincerely appreciate the activities of the Botanical Society of Edinburgh, and particularly the great influence it has had in furthering taxonomic botany and botanical exploration. The long list of its members who have played a prominent part in the affairs of the Society includes many who have added lustre to British Botany, and its "Transactions and Proceedings" bear testimony to the way in which it has carried out its main object, that of advancing man's knowledge of plants.

The Trustees of the British Museum in sending greetings confidently hope that the Botanical Society of Edinburgh will continue to flourish and to maintain its high traditions.

COSMO CANTUAR, *Chairman of Trustees,*
C. TATE REGAN, *Director, of the British Museum (Natural History).*

June 27, 1936.

FROM THE ROYAL BOTANIC GARDENS, KEW, TO THE BOTANICAL SOCIETY OF EDINBURGH

Greeting. On the auspicious occasion of your Centenary we gratefully recall how your Society, from its foundation, has promoted the study of Systematic Botany under the

stimulus of your first President, Robert Graham, and of such eminent botanists as Robert Kaye Greville, John Hutton Balfour, Hewett Cottrell Watson, William Lauder Lindsay, and Richard Spruce.

The impetus thus given to the study of Botany has been ably sustained during the past hundred years of your existence and has covered a wide field of botanical investigation, especially among the Cryptogams, both at home and abroad.

Not only has the Society published important monographs, but it has also encouraged the publication of many smaller papers, the interest and value of which, coupled with the flourishing condition of your membership, are a fine testimony to your vigour.

It is, we feel, a happy augury for the future that your Secretary is a member of the clan of your original President, and in tendering you our Congratulations we also offer you our Good Wishes for your continued usefulness and prosperity.

ARTHUR W. HILL, *Director*.

July 1, 1936.

UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, TO THE PRESIDENT AND COUNCIL OF THE BOTANICAL SOCIETY OF EDINBURGH

Greeting. Know ye that we the Trustees of the University of Pennsylvania do hereby designate and appoint the bearer of these letters, Wesley Gillis Hutchinson, M.A., Ph.D., Assistant Professor of Botany, to be our delegate for us and in our stead attend the celebration in honor of the Centenary of the Society to be held on July the first, nineteen hundred and thirty-six, and there to present in person our felicitations and sentiments of high regard.

Given at Philadelphia, Pennsylvania, under the seal of the Corporation, this nineteenth day of May in the year of our Lord one thousand nine hundred and thirty-six, and in the year of the University the one hundred ninety-fifth.

GEORGE A. BRAKELEY, *Vice-President*.
Attest E. W. MUMFORD, *Secretary*.

UNIVERSITAS CANTABRIGIENSIS
SOCIETATI BOTANICAE EDINBURGENSIUM

Salutem. Cum nobis nuntietis mox finitum iri centesimum annum, ex quo ordinata est Societas vestra, et iubeatis nos partem in caerimoniis vestris saecularibus habere, delegamus professorem nostrum Albertum Carolum Seward, diu in re Botanica probatum, qui praesens vobis declaret voluntatem nostram. Quod tot per annos studio tam utili tam iucundo tantos labores impenditis, et annos pariter felices expectatis, valde gaudemus. Scimus apud vos esse hortum multis Botanicorum triumphis insignem; scimus semper Scotiam hortulanorum matrem fuisse optimorum; meminimus item illud philosophi nostri placitum, qui dictitabat voluptatem purissimam esse horti studium. Talibus auguriis quis dubitet de felicitate futura?

DABAMUS CANTABRIGIAE,
anno Salutis nostrae mcmxxxvi
die quinto decimo mensis Maii (cum sigillo)

THE UNIVERSITY OF ABERDEEN.

The University of Aberdeen joins with other Universities and Learned Societies in congratulating the Botanical Society of Edinburgh upon the Centenary of its Foundation.

The three illustrious names that cover these hundred years recall the bond that has united the Society with the University of Edinburgh and the Royal Botanic Garden, to the advantage of Science. Under the guidance of Robert Graham, John Hutton Balfour, and Isaac Bayley Balfour, the Society strengthened the ancient ties between Botany and Medicine, fostered the study of the Flora of Scotland and other lands, and opened new inquiries into the problems of Horticulture, Agriculture and Forestry. Through the long series of its "Transactions," in which are incorporated such classical works as the *Hepaticae Amazonicae et Andinae* of Richard Spruce, members of the Society have enlarged knowledge; and the University of Aberdeen gratefully bears witness to

the quickening impulse received by Botanists, far beyond the University and City of Edinburgh, from the labours of the Society.

W. H. FYFE, *Principal.*
H. J. BUTCHART, *Secretary.*

THE CENTENARY OF THE BOTANICAL SOCIETY OF EDINBURGH 1836–1936.

THE SENATUS ACADEMICUS OF THE UNIVERSITY OF GLASGOW TO THE BOTANICAL SOCIETY OF EDINBURGH.

From this our ancient University in the West of Scotland we send our cordial greetings to the Botanical Society of Edinburgh on the happy occasion of the Centenary of the Society.

The University of Glasgow is aware of the important achievements of the Society in furthering the advancement of Botanical Science in Scotland and, in congratulating the Society on the notable results of the sustained effort of a century, we feel confident that the flourishing state of the Society is a sure augury of fruitful service to Botanical Science in Scotland in centuries to come.

RALPH STOCKMAN, *Chairman.*
J. R. CURRIE, *Clerk of Senate.*

ADDRESS DELIVERED AT THE CENTENARY MEETING, JULY 1, 1936,

By Professor F. O. Bower, Sc.D., LL.D., F.R.S.

We meet to-day to celebrate the Centenary of the Botanical Society of Edinburgh. The period when it was founded was one of reconstruction and varied initiative. The year 1836, like our own day a century later, fell in a time of recovery after a great international upheaval. War had devastated countries, and depleted exchequers. It had given peoples and individuals alike seriously to think. Not only reviving industries but also quickened mentality then showed nascent qualities, like chilled and super-saturated solutions roughly shaken. But often the reaction, whether in industry or in the arts and sciences, is not sudden like the formation of crystals from an overcharged solvent. Post-war developments are apt to take time in their maturing; the time-lag may even extend to decades before the reaction becomes apparent by results, whether material or mental. But the initiative may have been none the less due to the prior shock.

History yields many instances of new initiative following on the impact of war, and with varying lag of time. The fall of Constantinople in 1453 is reputed to have started the trek of learning from the East through Europe. The Renaissance, reaching the westward seaboard, flowered fully in the glories of Elizabethan literature. In Science it took the form in Britain of Bacon's "Novum Organum" (1620). Later a fresh local stimulus was provided by the disturbances of the Cromwellian period. These were closed by the Restoration and Monk's entry into London in 1660. In 1662 the Royal Society was founded by Charter, realising in some degree Bacon's ideal revealed in the "New Atlantis." Here the time-lag was uncommonly short. In 1681 the Edinburgh College of Physicians came into existence. Passing to the eighteenth century, Quebec fell in 1759, and the Treaty of Paris was signed in 1763, while the surrender of Cornwallis in 1781 closed the American War of Independence. These events were followed by the foundation of the Manchester

Philosophical Society in 1781, of the Royal Society of Edinburgh in 1783, and of the Royal Irish Academy in 1786. A crop of olive branches thus followed close on peace. Soon, however, the French Revolution broke out, with its trail of war culminating at Waterloo in 1815. The more settled times that followed were marked by further scientific developments in northern Britain. Four new Regius Chairs were instituted in Glasgow in 1816, of which that in Botany was one. The Yorkshire Philosophical Society came into existence in 1822, the British Association in 1831, and the Botanical Society of Edinburgh in 1836. Lastly, and most important of all, the year 1836 witnessed the foundation of the University of London. Such sequences of events can hardly have arisen from mere coincidence. I think we may reasonably believe that a causal relation existed between public disturbances and new beginnings of various orders.

Be this as it may, Sachs opens the fifth chapter of his "History of Botany" with the remark that: "In the years immediately before and after 1840 a new life began to stir in all parts of botanical research: in anatomy, physiology, and morphology." He might well have added inquiry into the nature and classification of species also. The Centenary which we now celebrate recalls that period of change, and the foundation of this Society may be held as a local instance of the renascent state of the Science. In earlier centuries the several branches of Botany were not clearly segregated as separate fields of observation or experiment. The Science was at first generally descriptive, with a view to the identification of food-stuffs, drugs and dyes, timbers and textiles. This was all summed up in the early Herbals, with gradually increasing precision in the grouping. The period culminated in the seventeenth century in such works as those of Bauhin and Gerard. The advance of the Science from a descriptive to a systematic treatment is traced by Sachs to the influence of Cæsalpino early in the seventeenth century; and it was developed later by Morison, Ray, and Tournifort, till Linnæus, in the eighteenth century, gathered up all that had been done before him and, with the aid of his binomial nomenclature, laid out in strict terms the artificial system that goes by his name.

However great the vogue and usefulness of that system proved at the time, Linnæus himself was not satisfied with

it. He constructed a fragment of a natural system based on a wider range of characters; and he declared that the chief task of botanists should be to follow on such lines. The names of De Jussieu and De Candolle are intimately related to its further development. A powerful stimulus was imparted by that golden age of foreign travel which followed in the early decades of the nineteenth century. Robert Brown collected plants with the Flinders expedition (1801–5); Darwin with the Beagle (1831–6); Hooker sailed with Ross to the Antarctic (1839–43); these exploits, together with Hooker's later Indian journeys, and Wallace's visits to the Amazon valley and to the Malayan Region, resulted in enormous accessions of fact upon which systematic method worked and developed. The Natural System was by this time fully established, but without any coherent theory of descent to co-ordinate the results. The period when this Society was founded was still pre-evolutionary.

But the year 1836 was also pre-protoplasmic. Though plant-anatomy was already well advanced, with its foundations laid by Hooke and Grew in the seventeenth century, and though their observations had been extended in the eighteenth by the phytotomists of the Continent, it was only the scaffold of cell-walls that they knew; the vital body which those walls enclosed was almost wholly missed. The functional protagonist, the protoplasm itself, was absent. Before 1836 sporadic allusions had already been made to the transparent slimy substance contained within the cell-walls. Interest had been taken in its granules, and suggestions made of vital motion. It was only in 1831 that the nucleus had first been recognised, by Robert Brown, as a body of general occurrence in the cells of plants; while the structural correspondence of the cell-contents with the sarcode of animals was first published by Schwann in 1839. Finally, it was not till 1846 that the word "protoplasm" was introduced by Von Mohl to connote "that viscid fluid of white colour . . . which occupies the cell-cavity." Von Mohl was indeed the founder of the cell-theory for plants; for he was the first who took up the all-important position that fibrous elements and vessels of the wood are formed from cells (1831). Thus the year 1836 fell within that brief nascent period when the cell-unit and the protoplast were emerging from obscurity

towards definite visualisation, making modern physiology for the first time possible.

The branch of plant-physiology had already made advances from the seventeenth century onwards; but at first these were of a macroscopic nature, as seen in the "Static Essays" of Hales, and in the studies of movement by Knight, Von Mohl, and others. Naturally the question of sex was raised early, though it could not be fully resolved till improved microscopic technique led to more exact observation; nevertheless the zoospores and sperms of many Cryptogams had been seen before our Society was founded. In flowering plants, Sprengel's "Entdeckte Geheimniss" of 1793, had established the grosser facts of intercrossing through the agency of insects, though it remained for Darwin and Müller to breathe new life into his data and ideas. Moreover, it required Robert Brown's discovery of the pollen tubes in 1831, and the detailed observation of the contents of the embryo-sac from Schleiden to Strasburger, to bring those grosser facts into their true relation to syngamy. The year 1836 fell between the era of surmise and that of demonstration of the actual facts of sex.

On the other hand, Nutrition had long before aroused the curiosity of Cæsalpino (1583) and other early botanists; but it offered more exact problems after the discovery of oxygen and carbon-dioxide. This led at the end of the eighteenth century to the recognition by De Saussure of photosynthesis and respiration. The opening of the nineteenth century also saw the study of endosmosis founded by Dutrochet. These and other advances were summed up in the "Physiologie Végétale" of De Candolle in 1832. Real progress, however, in physiology required greater precision of microscopical technique than these writers could command. The defect was remedied by Von Mohl in the earlier decades of the nineteenth century. The book before all others that marked the path of improving technique was his treatise "Die Vegetabilische Zelle" (1851), in which he summed up as a continuous whole the gist of his scattered memoirs of the previous twenty years. From it we learn how fruitful was the period at which this Society was founded in that knowledge which underlies the later advances in Plant-Physiology.

Lastly we come to Morphology, the study of form which, though not always recognised as such, really comprises the

result of all the other branches of botanical inquiry. In the eighteenth century much descriptive detail had become available from earlier writings; but the first general conception of plant-form appeared in the "Theoria Vegetationis" of C. F. Wolff (1759), which was naturally at that period based upon comparison of the flowering plants. In restating his phytonic theory in 1766 he said that "he saw nothing ultimately in the plant but leaves and stem, including the root in the stem." After nearly two hundred years we find this statement to accord substantially with the recent Telome Theory of Zimmermann (1930). Then followed the Theory of Metamorphosis of Goethe (1790), and the Spiral Theory of Schimper (1830), restated later by Braun (1835). All of these writers were steeped in the Nature Philosophy of the period. But an antidote to its preconceptions was soon found in the comprehensive textbook of Schleiden ("Die Botanik als induktive Wissenschaft," 1842). His primary object was to substitute a spirit of genuine inductive inquiry in place of the preconceptions from which those writers started. In particular, Schleiden gave special prominence to embryology, and insisted upon the history of development as the foundation of all insight into morphology. In this he was followed by Naegeli, who went straight to the application of the laws of induction, maintaining that it is only in this way that facts and observations have any scientific value. Thus two centuries after the publication of the "Novum Organum" the principles laid down by Bacon at last found their full application in Botany. Plant Morphology then took its place as a branch of Natural Science on the same footing as Physics and Chemistry (Sachs). This result coincided very nearly with the foundation of the Botanical Society of Edinburgh. Once more we realise the insight of Sachs, when he noted how the years immediately before and after 1840 marked a period of reincarnation of Botanical Science.

Drawing these various aspects of the Science together we can reconstruct in some measure the arena of 1836. Purely descriptive Botany, enriched by the large collections of the golden age of travel, was passing from artificial methods of classification into a gradually moulded Natural System. Even Ecology, though not then known by that name, was being practised in a rudimentary form but on a grand scale by

Darwin and Hooker. Their prescience, combined later with the evolutionary vision shared by Wallace, was opening the question of mutability of species as against their fixed origin by special creation. This had already been glimpsed by Elias Fries in his "Corpus Florarum" of 1835, when he found "*quoddam supernaturale*" in the Natural System. So long as the constancy of species was still maintained Systematic Botany would fail to render a scientific account of Nature. But the new wine had already raised a dangerous pressure in the old systematic bottles at the time when this Society was founded. On the other hand, knowledge of Anatomy was deficient in the most essential facts. The protoplast with its nucleus had not been recognised as the physical basis of life and of heredity. Thus far Hamlet had been missing from the stage; but now he was seen just entering through the wings, and the drama of physiology was beginning to unfold upon a new footing of vitality. In Morphology the age of preconceptions was drawing to a close, and the inductive method was about to take their place under the influence of Schleiden. His insistence on embryology and development paved the way for the search into life-histories, which marked the next stage of the story. But this could not receive its true comparative meaning under a belief in special creation. The facts remained sterile till the magic touch of evolutionary theory awoke them into life. There was then an atmosphere of expectancy abroad in the leading branches of the Science in 1836, when the Botanical Society of Edinburgh was founded.

However impressive these early advances in botanical thought and achievement may have appeared to the original members of the Society in 1836, their effect was to open the way for still greater results during the period that followed. We may try to restore the picture of further development as it presented itself during the first half-century after the incorporation. The greatest event of all was the coming of Evolution, heralded by the famous letter of Darwin to Hooker, in January 1844; within a decade of our foundation. "At last gleams of light have come," he said; "I am almost convinced that species are not immutable." This was probably the first communication by Darwin of his species-theory to any scientific colleague. What followed we all know. As a shaken kaleidoscope makes a new pattern from its fragments

of coloured glass, so the facts derived from living things, hitherto accumulated rather than methodised, found new relations of intelligible beauty. Anatomy, Physiology, and Classification all gained new aspects under the theory of Evolution. But of all the branches of Biology it was Morphology that became the most arresting topic; as Darwin himself said: "It is one of the most interesting departments of Natural History, and may almost be said to be its very soul." As the century progressed the scope of Morphology widened from a mere study of external form and constitution of the adult shoot in the higher plants, and of the construction of the mature flower. Under the influence of Schleiden the *voir venir* became essential in each problem of form. In practice an overruling preference for the earlier stages even led sometimes to a neglect of the adult state. A right balance, however, brought an added knowledge of the whole cycle of development; and this was so not only for the higher vegetation but also in the Archegoniatæ and the Thallophytes. The middle of the nineteenth century thus became a period of tracing of "life-histories," and its greatest exponent was Hofmeister himself. It was his masterly synthesis of the facts of the whole life-cycle in Archegoniate plants that gave those facts their real significance; with the result that an underlying scheme was detected for them all, with alternating sexual and neutral phases. While we point to this as a crowning achievement which laid the foundation for Morphology in a new and extended sense, we should not forget that many other workers were taking their part in the completion of life-histories; among Liverworts and Mosses, in various Algæ both marine and of fresh water, and even in Fungi. After a century of such work we now have before us all the essentials of the life-cycle in Thallophytes, Archegoniates, and Seed-Plants; though these still provide material for discussion as to their origin, stability, and significance. Our earliest members will have witnessed the first of these discoveries, and we ourselves have seen the scheme of phases gradually assuming a general application as the phenomenon of "Alternation of Generations."

Meanwhile intensive study of the nucleus and its behaviour during division was following close upon the improvement of lenses, and of microscopic technique. The foundations of

cytology were being laid, and nowhere with such precision as in Bonn, where Strasburger observed and taught. What could be more natural than that the differences of haploid and diploid chromosome-number should be correlated with syngamy and reduction, and a cytological distinction recognised between the normal alternation of gametophyte and sporophyte? The famous statement on Periodic Reduction was made by Strasburger at the meeting of the British Association at Oxford, in 1894. Within three months of its delivery I had the honour of discussing it before this Society in my presidential address of that year. The cytological facts thus threw a new light on the Hofmeisterian cycle; though forty years later, their interpretation remains still open for discussion.

The second half of the century in the history of our Society has witnessed the development of Botany along many divergent branches of specialisation, which, though cognate, are often pursued with a dangerous exclusiveness. Specialist's myopia is a disease that may threaten the scientific balance of any enthusiastic inquirer. The wider the spread of the science in its relation to cognate sciences the greater the danger becomes of pursuing a restricted or an extreme marginal cult, as it were between blinkers. The blinkered horse keeping the straight road does not visualise the countryside he traverses; and so the individual specialist is apt to miss the wider aspects of the science, specific details of which he pursues. It is here that a Society like ours may take an increasingly valuable place in these modern days of high specialisation, and of interests localised but divergent. It will naturally aim at welcoming into its proceedings all branches of the Science upon an equal footing. The general discussions which follow a detailed statement of facts submitted by one who cultivates a limited area would tend to amalgamate those facts into the substance of the whole science; bringing to it, as in an alloy of metals, new qualities of strength, resistance, and stability.

It is a good thing for any one from time to time to review his position, not only in respect of his own branch of science, but in relation to Science as a whole. He should take time to consider whether or not his enthusiasm or his limitations may require correction, so as to maintain a just poise. But

if this is wise for the individual, how much more may such a review have its value when applied collectively to the votaries of a science, or even to its balance among the related sciences. It is here that the meetings and discussions of societies such as ours have a still wider value. Those who cast their eyes abroad in this way will perceive that the progress whether of an individual adherent of a particular science, or collectively of the representatives of that science, is not equable. Advances are apt to be made, in either case, by fits and starts. Sometimes they are dictated by important discoveries of fact, or by syntheses which give new aspects to facts already known. The herd-sense may thus be aroused, and a general tendency be developed to follow lines of least resistance by multiplying instances of what has been already demonstrated. Such results easily convert themselves into what is little more than a temporary fashion. Certain sciences, or certain aspects of a single science, may thus come prominently before the public eye, and enjoy a vogue; but this is liable to wear out so soon as difficulties of further observation, dearth of facts, or exhaustion of the new vision make resistance to progress again a positive deterrent. The fashion then fades, or dies of inanition. This is no fancy sketch. Anyone who follows the history of scientific progress can readily find instances on a larger or a lesser scale. The meetings of the British Association serve as a mirror reflecting how certain subjects come to the middle of the stage, or fall back. For instance, in the sixties of last century there was an on-coming wave of biological enthusiasm following on the Theory of Evolution. Now the pendulum has swung to cosmic questions, under the influence of discoveries from the atom to the nebula. The biological sciences meanwhile tend to pass under a temporary eclipse.

It is the same with any individual science as it differentiates into distinct branches; as Botany has done in recent years. An ebb and flow of interest follows in the pursuit of each of these. New syntheses, or new facts, guide the stream of research, and now one branch now another starts into prominence, becoming for a time a popular field of inquiry. For instance Von Mohl's visualisation of protoplasm founded the physiological renaissance of Sachs and his school. Schleiden's insistence on the history of development as the foundation

of all insight into morphology led to Hofmeister's great synthesis, and paved the way for the Organography of Von Goebel. De Bary's Comparative Anatomy preluded the stele-theory of Van Tieghem, and the physiological anatomy of Haberlandt; while his fungal researches provided the initial steps of infective pathology. Strasburger's nuclear researches laid the foundation for modern cytology and genetics. Bornet and Thuret in their "Études Phycologiques" led up to the Algology of Oltmanns and Svedelius. The French Palæophytologists were the natural precursors of Williamson and Scott; while the Röragen Flora of Halle heralded the discovery of many new plants of early Devonian Time. These and other lines of specialisation, particularly those on the borderline of physics and chemistry, characterise modern botanical research, and all should find a common meeting-ground in such a Society as ours.

Few can expect to follow to-day a plurality of these lines to the fringe of present knowledge. The day of the specialist is upon us, with its choice of lines for detailed study. In this, as we have seen, fashion and opportunity are determining influences. At the moment Cytology, Genetics, and Palæophytology, together with Physiological Chemistry and Physics, are in the ascendant, while the old fundamental branches are more static. This was specially noted by Von Goebel in respect of Morphology. In his last letter, written to me a few months before his death, he expressed disappointment that enthusiasm for Morphology was not more widely spread at the present time. "Nowadays (he wrote) small attention is bestowed on anything but genetics and experimental physiology." Nevertheless he added the hopeful words, "aber die Zeit wird kommen." They give me a text for my concluding paragraphs.

In the ardour of their pursuit of special branches of research, few of those thus engaged take the larger view of relating their results to the whole evolutionary problem. Each demonstration may be, and commonly is, pursued as an end in itself, while the scope of the whole problem is not fully realised; which is, to ascertain, so far as is possible causally, how plants as we see them came to be such as they now are. This modern aspect of Morphology must be built up by co-ordination of the results of all investigations that affect form. This

is a very different thing from that idealistic study for which the name of Morphology was introduced by Goethe. It accords more nearly with the broader vision of Schleiden, which was based upon induction from observed facts. But it is far enough still from realisation. Nevertheless it is from such sources that a truly scientific morphology may gradually emerge. Hitherto semi-poetic guess-work, largely based upon preconceptions, has been too much in evidence, passing under the guise of morphology. But if the embryo from the moment of definition of its polarity be visualised as a plastic shoot-unit, with its apex defined as an inherited feature in relation to a substratum, then an approach is made to a starting-point for the treatment of the adult shoot based upon observed fact. The future of such a scientific morphology of cormophytic plants as this does not lie in the details of the adult form; it is to be sought rather in a renewed examination of the growing-point of the shoot-unit, and of the continued embryology that is centred there. Having made a lifelong study of primary meristems, dating from attendance in Sachs' laboratory in 1877, I may venture to suggest to those who will carry on such work an aspect of the apical cone that offers a high degree of freedom from preconceptions. It is now generally agreed that segmentation in the apical region and the genesis of appendages are two separate propositions. The results may sometimes correspond; as for instance when each apical segment forms a leaf, as in Mosses and in some Ferns. But this is only an occasional event. Such correspondence is in fact optional for certain types of plants; it is not obligatory for all. If this be admitted the whole apical region may be regarded as a septate and encysted plasmodium, capable of forming outgrowths independently of cell-cleavages. In a sense its behaviour would be amœboid, though under the restriction of encystment, which rules out retraction of an outgrowth once initiated. The lobes thus formed would possess from the first a stability such as the pseudopodia of *Amœba* have not, and such stability would be liable to persist as an inherited character. As to the number and relative position of those lobes or appendages Von Goebel definitely refers their origin to conditions of growth and symmetry that arise in the growing-point, which plays not a passive but an active part in their determination. On the

other hand, it has been reasonably suggested that a localisation of hormones in the apical region is a precedent condition for the outgrowth of appendages. Probably the same will also hold for the inner tissue-tracts. Such localisation may be referred to an inner heritable initiative of the apical region itself.

This is not the time or the place for detailed discussion of such broad questions as these, nor are the necessary measurements yet available for founding a settled opinion as to the place which the size-relation of parts composing the shoot-unit may take: for instance, in the problems of phyllotaxy, or the definition of elaborately moulded conducting tracts. But an occasion like the present seems to be propitious for suggesting this "amœboid" point of view of the embryonic unit acting as a whole which, so far as the features are inherited, would be initially independent of the impress of external conditions. In doing this I think I shall be realising at this Centenary Meeting, one of the primary functions of a Society such as ours. It should not be a mere receiver for results contributed by members with a view to their publication, however important this function actually is. It should also be held as an arena for criticism; but most important of all it should supply the stimulating effect of contact of one mind with another in relation to nascent questions.

I have not attempted in this address to trace any continuous thread of the history and achievements of the Society itself. This is embodied in the following pages from authors better informed for that purpose than I could possibly be. My object has been to place the century of its existence, the completion of which we now celebrate, in its relation to the progressive stream of the Science of Botany at large. Who can tell what the future may hold for those who come after us? But looking back we cannot fail to see that the century now closed has witnessed wonderful advances not only of fact but also of vision. To other forward movements as they arise this Society will be as fully alive in the years to come as it has been in the past.

A SURVEY OF THE ACTIVITIES OF THE BOTANICAL SOCIETY OF EDINBURGH.

1. Systematic Work (Phanerogams and Vascular Cryptogams).

Instituted on the 17th of March 1836, the Botanical Society of Edinburgh issued a Prospectus of its Laws and intended activities at its first open meeting, held on the 14th of April following. From this Prospectus it is clear that the formation of an Herbarium and the exchange of dried specimens of plants were at that time the Society's main objects.

"The operations of the Society," we there read, "will for some time be confined principally to the holding of Periodical Meetings,—to Correspondence,—to the formation of an Herbarium,—and to the establishment of a Medium of Intercourse for the exchange of Specimens between Botanists at home and abroad. . . . The value of an authentic Herbarium, especially to the resident Botanist, must be obvious; and this will, therefore, receive particular attention. The peculiar feature, however, in the constitution of the Society, is the provision made for the interchange of Specimens. . . . The Flora of Edinburgh, which is particularly rich, will afford a constant supply of valuable duplicates, and many rare species will be annually obtained from the mountainous parts of Scotland."

That the exchange of specimens was contemplated on a large scale may be seen from the Laws of the Society. To enable him to participate in the distribution of specimens, a Resident Member was required to contribute yearly "not less than fifty species of Plants, with as many duplicate specimens of each for distribution as possible"; while a Foreign Member's obligation amounted to "500 specimens (including at least 100 species)," at the time of his election, and "300 specimens, including at least 50 species," annually thereafter.

Under the enthusiastic guidance of such men as Professor Graham, Dr. R. K. Greville, Dr. Hutton Balfour, Dr. Patrick Neill, and James McNab, the Herbarium thus started grew so rapidly that it soon became a burden to the Society. In

1839, after only three years, it contained no less than 150,000 specimens, and its accommodation was an acute problem. Arrangements were then made, by courtesy of the Senators and Patrons, to have it housed within the walls of Edinburgh University, under the designation "University Herbarium"; but with the Botanical Society still as curators. To it was added, at the same time, the "College Herbarium," dating from the days of Dr. John Hope (1761–1786), but fallen into neglect, which contained some 1100 species. By 1842 this joint Herbarium was regarded as "nearly complete"; but thereafter the failing health of Professor Graham, and the scattering of those most keenly interested, caused a great decline in activity, which never again reached its first fervour.

While this decline in enthusiasm may be regretted in some ways, it can only be regarded as fortunate in others. It is on record that, in 1838, the Society had from Robert Gardiner of Dundee alone some 3000 specimens collected by him in the Perthshire mountains. Many others were equally busy, and the almost ruthless gathering of the rarer alpine and even local plants rapidly began to have its inevitable effect. After an excursion in Perthshire during August 1839, Professor Graham was constrained to write as follows: "The usual Ben Lawers plants were found at the top and on the west side, but in much smaller quantity than formerly, and the specimens of *Myosotis alpestris* were generally miserably small. The mountain has for some years been too frequently visited by collectors, and the plants too carefully gleaned." At the same time he remarks, of an adjacent locality: "I feel quite certain that this is untrodden ground, for no collector could have left such specimens as we gathered of *Draba rupestris*; specimens many times larger than I ever saw before. . . ."

One cannot but feel glad that the student of Botany to-day has an altered outlook, compared with his predecessor of one hundred years ago, and has largely lost the collector's covetousness of specimens, rare or fine, merely as such.

By 1853 the "University Herbarium" had so increased in extent that only the British section of it could be conveniently housed at the University, and at that date the foreign collections were removed to "a commodious room in the new

Museum" at the Royal Botanic Garden. In 1863 the Society lost the use of the "Herbarium Rooms" at the University, which were needed for other purposes, and shortly thereafter the two sections were reunited at the Botanic Garden. There they still remain, and have formed the nucleus around which has been built up, under successive Regius Keepers of the Garden, the present very extensive Herbarium of that Department, housed and cared for by Government, and comprising upwards of a million and a half sheets of specimens. Rich in material from most areas, this Herbarium is unique in the full representation it possesses of the flora of Western China, that being largely due to the magnificent work done there during many years by the late Mr. George Forrest, an Associate of this Society.

Amongst the numerous acquisitions of value in the earlier days only a few can be mentioned here. In 1837 Christina, Countess of Dalhousie, presented her entire East Indian collection; about 1840 the Hon. East India Company sent a fairly complete series of Dr. Wallich's material; while in 1860 there was given a set of Hooker and Thomson's Himalayan specimens. After his death, in 1866, the entire phanerogamic herbarium of Dr. R. K. Greville was acquired: while from South America came over 6000 of Dr. Spruce's plants of the Amazon and Andes, between 1852 and 1857; and shortly afterwards a set from Peru and Brazil gathered by Dr. Jameson.

A special interest in the cultivation of unusual plants led Mr. Charles Jenner to propose, in March 1868, the formation of an "Alpine Botanists' Club," with the object of financing and sending out annually "two competent young botanists to some desirable districts of limited area in the Scottish Highlands" to obtain for subscribers specimens, living or dried, of "new or rare cryptogamic and phanerogamic plants." A committee was formed to consider the proposal, but nothing further was done. Two years later, however, worthier expression was given to that delight in the mountains of Scotland and their flora, characteristic then as now of so many of the Society's members, by the formation of the "Scottish Alpine Botanical Club." This inner circle of the Botanical Society of Edinburgh was instituted on the 10th of August 1870 at Bridge of Lochay Hotel, Perthshire, during a week's

botanical exploration of the neighbouring peaks; among the ten original members were Professors Dickson and Hutton Balfour, John Sadler and Isaac Bayley Balfour. Membership was—and still is, for the Club continues to flourish—confined to those "who are in the habit of visiting alpine districts of Scotland for the practical study of science, and who have proved themselves to be pleasant *compagnons de voyage.*" In addition, no one was to be admitted "who had not proved that he had ascended on foot to the summits of three Scottish mountains, not less than 3300 feet above the level of the sea." Throughout its long life the Club has annually carried through at least one excursion programme of several days' duration, and the annual Reports dealing with these are printed in the *Transactions* of the Society. The activities of the Club have added not a little to our knowledge of Scottish botany. During the excursion of August 1874 *Salix Sadleri* Syme (*S. herbacea* × *lanata*) was discovered; while in 1883 the remarkable and still somewhat obscure *Sagina Boydii* F. B. White was found. Additional stations for many Scottish rarities, for instance *Thlaspi alpestre* L., *Saxifraga rivularis* L., *S. caespitosa* L., and *Gentiana nivalis* L. have been recorded; while old and doubtful records, such as those of *Carex atrofusca* Schkuhr and *Cystopteris montana* Link from Ben Lawers, have been re-established by its members.

An examination of the pages of the *Transactions* of the Society shows how continuous and close has been the relationship between the Society and students attending the Classes of Botany at Edinburgh University. In connection with these classes it has always been the practice to hold frequent excursions for the study of plants in the field, and records of the species observed on such occasions will be found scattered throughout vols. i to xiii, along with many lists of plants met with by former students during their vacations at home and abroad. Not a few, after graduating, became attached as medical men to expeditions of importance and communicated regularly with the Society while so engaged. Some idea of the extent and value of this to the Society may be had from the fact that, at the Meeting held on 8th July 1858, letters were read from Drs. Balfour Baikie, John Kirk, and James (later Sir James) Hector, then attached respectively

to the Niger Expedition, the Livingstone Expedition in Central Africa, and Pallisier's North American Expedition.

Again, the pages of the Society's *Transactions* show how closely its members have kept in touch with current advances in knowledge of the British Flora. In his time, Professor C. C. Babington contributed many papers, some of considerable importance. His "Monograph of the British Atriplicae" will be found in vol. i, and his "Synopsis of the British Rubi," with Supplements, in vols. ii and iii; while there are treatises by him on such critical genera as *Fumaria*, *Viola*, *Saxifraga*, *Oenanthe*, *Epilobium*, *Arctium*, and *Statice* in these and subsequent volumes. From 1885 to 1925 very numerous papers and notes on similar subjects appear under the name of Arthur Bennett. Other contributors well known in connection with British Botany are R. K. Greville, H. C. Watson, T. Bell Salter, John Bell, T. Townsend, John T. Syme, J. Hutton Balfour, F. Buchanan White, Lauder Lindsay, E. F. Linton, G. C. Druce, A. Scott Elliot, and many more. In vol. ii the Rev. W. H. Coleman first separated and diagnosed *Oenanthe fluviatilis*, till then confused with *Oe. aquatica* Poir.; and in vol. xiii appeared the first description of *Hieracium Dewari* Boswell.

Foreign systematic botany has frequently occupied the attention of the Society, in particular during the years 1905 to 1925, covered by vols. xxiii–xxix, when the rich collections made in Western China by Mr. George Forrest were being worked out. It is impossible to cite even a portion of the papers on this aspect of botany published during these years, but, taking vols. xxvi and xxvii alone, the following important contributions were made to the Botanical Society by Sir Isaac Bayley Balfour:—"The Primulas of the Bullatae Section"; "Primula obconica and its Microforms"; "The Saxifrages of the Diptera Section"; "Rhododendron trichocladum and its Allies"; "Rhododendrons of the Irroratum Series"; "Some late-flowering Gentians"; and "The Genus Nomocharis." In the same two volumes appeared numerous papers by other authorities on various groups: by Sir William Wright Smith on *Rhododendron*, *Primula*, *Compositae*, and many scattered genera; by Professor J. Small on *Compositae*; by Dr. Schindler on *Leguminosae*; and by Dr. R. Ll. Praeger on *Sedum*. In addition to numerous new species and varieties

in existing genera, no less than eight new genera were described in the Society's *Transactions* during the period under consideration, namely: *Borthwickia* W. W. Sm. (*Capparidaceae*), *Cavea* W. W. Sm. et J. Small (*Compositae*), *Craigia* W. W. Sm. et W. E. Ev. (*Sterculiaceae*), *Formania* W. W. Sm. et J. Small (*Compositae*), *Parasyringa* W. W. Sm. (*Oleaceae*), *Parasenecio* W. W. Sm. et J. Small (*Compositae*), *Wardaster* J. Small (*Compositae*), and *Whytockia* W. W. Sm. (*Gesneraceae*). In vol. xxviii, it should finally be mentioned, appeared Sir Wm. Wright Smith's "Notes on Chinese Lilies."

W. E. EVANS.

2. CRYPTOGAMS (non-vascular).

In the first publications of the Society—the Annual Reports 1836–1846—only scattered references to cryptogams occur. Among them, however, are references to the discovery of *Phycomyces nitens* and *Buxbaumia aphylla* in Scotland, and these probably constitute first records. In the early years, indeed, the members were interested chiefly in flowering plants, as is well indicated by the fact that of 402,000 specimens received for the Herbarium in 1839 only 1200 were cryptogams.

In the earlier years a considerable number of papers appeared on the Algae. These for the most part deal with the marine algae, and include papers on new species of *Sargassum* by R. K. Greville in 1849, the distribution of Marine Algae in the Forth by Rattray in 1885, the Marine Algae of the Dunbar Coast by G. W. Trail in 1885, and the Marine Algae of the Orkney Islands in 1886 by the same author. More recently W. and G. S. West communicated an account of the Freshwater Algae of Orkney and Shetland in 1905.

Papers on the Diatomaceae and Desmidiaceae have appeared by Dickie, Ralfs, Greville, and others, one of the most important being that by Ralfs on the British Desmidieae in 1844. In fact the last paper published in the *Transactions* by R. K. Greville, in 1866, was on a number of New and Rare Diatoms from the Tropics. An important account of the British species of Chara published by C. C. Babington in 1853 may also be mentioned here.

Only comparatively few contributions dealing with the fungi are found in the *Transactions*. An interesting early account of the potato disease was published by Goodsir in 1846, in which he referred "to the opinion generally gaining ground that certain epidemics owe their existence to the growth of fungi" and considered that "we are bound not to overlook the fungi which exist in the diseased tubers." Other early contributors of papers on fungi are J. Hutton Balfour and John Lowe. In 1857 S. J. Meintjes gave an account of an epidemic of *Oidium Tuckeri* at the Cape and its control by the application of sulphur.

Between 1870 and 1880 M. C. Cooke undertook the reorganisation of the fungus herbarium at the Royal Botanic Garden and contributed a number of mycological papers, the most important being an enumeration of the species of *Polyporus*. In 1888 an important paper on the fungi collected in Hardanger by J. W. H. Trail was published, in which many new species were described. During the same year the author also gave an account of the plant galls of Norway. In 1898 R. A. Robertson described the witches' brooms of various trees, and A. W. Borthwick contributed a paper on the same subject in 1899. The latter author at later dates also contributed various papers on fungal diseases, especially those of forest trees.

In 1934 appeared a long paper giving the distribution of the Uredineae in Scotland by M. Wilson.

A series of papers by W. Lauder Lindsay was published between 1862–1869 dealing with the cryptogamic flora of various countries, and especially with the lichens, the more important of these being the flora of Iceland (1862), of Otago, New Zealand (1886), and Greenland (1869). He also contributed the following papers on lichens:—"The Lichen-Flora of Druidical Stones in Scotland" (1867) and "Arctic Cladoniae" (1867). Carrington, Stirton, and others, have also published contributions on this group.

The taxonomy and distribution of the Bryophyta is a subject on which papers have appeared throughout the whole period. During the earlier years contributions on this subject were made by Dickie, T. Taylor, and Greville, and later on by Howie and Schimper, Stirton, Buchanan White, Ferguson, Bell and Sadler, W. Evans, Carrington, H. N.

Dixon, and others. Although the majority of these were concerned with Scotland, papers on the distribution in several other countries were also published, *e.g.* "The Musci and Hepaticae of the Pyrenees," by Spruce in 1849, and those of Spitzbergen by J. Hagem in 1908. The most important contributions dealing with this subject were "The Hepaticae of South America," by R. Spruce in 1885, which occupies the whole of volume xv and contains descriptions of many new genera and species, and "The Distribution of the Hepaticae in Scotland," by S. M. Macvicar, published in 1910, which occupies the whole of volume xxv.

In a consideration of the papers published on cryptogamic plants it is of interest to note that although the majority are concerned with distribution they are not by any means confined to a consideration of Scotland, but deal with regions as far removed as Australia, New Zealand, South America, and Greenland.

Papers on morphology and physiology are less numerous, and were for the most part published during the present century, although some are found throughout the whole period.

While work on all the classes is represented, perhaps the most numerous and important contributions deal with the Bryophyta, especially the Hepaticae.

Our amalgamation with the Cryptogamic Society of Scotland last year will doubtless increase the interest of the Society in this branch of botany.

M. WILSON.

3. ANATOMY AND HISTOLOGY.

So far as anatomy and histology are dealt with in the thirty-one published volumes of the *Transactions* certain very different trends of investigation can be discerned. At first attention was focussed on the cell itself. Subsequently the chief interest was transferred to investigations concerned with the destiny of the homogeneous cells as they differentiate in the establishment of the tissue systems of the plant. Still later these formal or morphological studies were applied to taxonomic and phylogenetic problems, and also to problems of physiology.

In the second volume of the *Transactions* Dr. (later Professor) George Dickie contributes a paper (1845) on "Fecundation in Plants." He reviews in this connection the work of Brown, Amici, Brongniart, Mirbel, and Schleiden. The last-named author had in 1837 announced that the extremity of the pollen tube is itself actually converted into the embryo. Dickie's contribution to the problem is the description of "ovule tubes" in Narthecium whose function he suggests is to secure the effect of the pollen upon the ovule. The difficulty of securing this effect is attributed to the large number of ovules and the awkward position of the "exotome." In 1848, in the third volume of the *Transactions*, the same author contributes a paper on the ovule of *Euphrasia officinalis*. His position has undergone a change, and "admitting that the pollen tube reaches the ovule" the action of the pollen in regard to the origin and the subsequent development of the embryo are considered. The paper contains much speculation in regard to the nature of the suspensor. Two years later, in 1850, John Scott Sandeman furnishes an account of the embryogeny of *Hippuris vulgaris*. Reference is made to the splendid contemporaneous researches of Hofmeister, Unger, and Tulasne, and the development described for *Hippuris* is claimed as typical of the higher plants. In 1855 Charles Jenner contributes a "Comparative View of the more important Stages of Development of some of the higher Cryptogamia and the Phanerogamia," in which he refers to Hofmeister's "Vergleichende Untersuchungen höherer Kryptogamen," which appeared between 1849–1851, but were not translated until 1862. This illustrates a recurring feature of the work of the Society where a member in touch with important botanical investigations abroad keeps his fellow-members abreast of such progress.

Excepting for a paper on "The Embryogeny of *Tropaeolum majus*" by Dr. Alexander Dickson (then in Aberdeen) in 1862 there is a break of twenty-four years before a further reference to histology occurs. By 1880 Strasburger had described the division of the nucleus, and its importance in cell division had come to be recognised. In 1881 Dr. (now Professor Emeritus) J. M. Macfarlane attacked the problem of the nucleus in a paper on the "Structure and Division of the Vegetable Cell." Special reference is made to the

nucleolo-nucleus, and detailed descriptions are given of the nucleus of *Spirogyra* and of *Equisetum limosum*. Allan E. Grant in 1883 dealt with the multinucleated conditions seen in a large number of flowering plants. This paper was one of two competitive papers for the Society's Student Prize of £10—a prize, one ventures to suggest, which might well be revived to mark our Centenary year. The break in anatomical contributions from 1855 to 1881 is indeed surprising, as J. Hutton Balfour came from Glasgow in 1845, and to Hutton Balfour Edinburgh owes the introduction of practical teaching of vegetable anatomy and histology.

The years following mark important advances in cellular study. In 1886 G. F. Scott Elliot presents a paper on the vegetable cell, reviewing the work of Schmitz (1880) and Strasburger (1882), and in 1891 and in 1892 Gustav Mann presents two papers. The second paper, "An Account of the Embryo-Sac of *Myosurus minimus*," covers seventy-seven pages, and is outstanding for its wealth of detailed observation and also for the extensive superstructure of speculation which still characterises much of the work of this period. However, in 1894, Professor F. O. Bower in his presidential address discusses the discoveries of Strasburger, who had formulated the generalisation that while the number of chromosomes was constant for each plant that number was halved at spore production and reassumed on the fusion of the gametes.

Another important forward step, the use of anatomy as an aid in taxonomy, finds early expression in the *Transactions*. In 1854 George Lawson contributes a paper on "The Cinchonaceous Glands in Galiaceae." In the succeeding volume the same writer contributes a paper on "The Microscopical Analysis of Tobacco." Descriptive papers are interspersed in the volumes until 1872, when Dr. Wm. Ramsay McNab contributes a paper on "The Organisation of Equisetums and Calamites." This contribution introduces Professor Williamson's work to the Society, though it denies that author's discovery of secondary thickening in the Calamite stem. In 1878 Isaac Bayley Balfour contributes an important paper on "The Genus *Halophila*," in which the aid of anatomy to taxonomy is well shown. Amongst the contributions of 1879 is one on "The Envelope of the Plumule of the Grass Embryo," by A. Stephen Wilson. This marks a stage in the

controversy over the homology of this structure which was cleared up only in 1931 in the remarkable paper on the Monocotylous Seedling by Dr. Lucy Boyd. In the years between 1879 and the present there have appeared numerous anatomical papers which though mainly descriptive yet have a bearing on taxonomy and on developmental anatomy. The most popular family for study is the Rubiaceae, while the Potentillae and other individual genera, e.g. *Banksia*, *Ruscus*, and *Mesembryanthemum*, were dealt with by R. A. Robertson and other workers.

The work of Haberlandt was introduced to the Society by G. F. Scott Elliot in 1885.

Among the papers in the early days of the present century occur two which are of considerable historical interest. In 1900 James Terras described the relation between the lenticels and adventitious roots of *Solanum Dulcamara*, thus antedating by twenty-five years the work of van der Lek and others on preformed roots. In 1909 James Waterston, in a paper on "The Morphological Changes induced in the Roots of Bromeliaceae by Attacks of *Heterodera*," describes the wound reactions that occur in plant tissues, and it is interesting to note that the endodermis is specifically mentioned. In 1915 Sophie J. Wilkie presents a paper on "The Influence of Different Media on the Histology of Roots." From 1922 onwards there occur two important series of papers. The first series deals with problems of regeneration in plants, and starts most appropriately with a paper by L. B. Stewart on "Juvenile Characters in *Acanthus montanus*." The histological changes occurring in regeneration are dealt with in numerous papers contributed by workers at or associated with the Edinburgh University Department of Botany. The second series of papers, with which the St. Andrews University Department of Botany is associated, starts in 1925. The investigations are concerned with ecological anatomy, and the publications cover the strand plants and the saltmarsh plants in the neighbourhood of St. Andrews. In vols. xxix to xxxi of the Society *Transactions* more anatomical papers are to be found than in the whole of the other volumes of the Society. These papers come mainly from the Edinburgh and the St. Andrews departments. The activity displayed in this field during the last decade of the century under

review augurs well for the immediate future, as a sound training in anatomy lies at the foundation of botanical training and investigation.

Notice must also be taken of the publication of papers dealing with methods of value to workers in plant anatomy and in histology. In 1868 William Ramsay McNab details the use of stains such as acetate of mauvine and Beal's carmine, while in 1881 Dr. J. M. Macfarlane gives methods for the use of aniline dyes, emeraldine, heliocin, and naphthaline. Gustav Mann in 1890 describes a method of embedding plant material in paraffin with chloroform as the intermediate solvent. In 1897 R. A Robertson communicated a paper on the "Photomicrography of Opaque Stems," and he also applied this method of recording anatomical structure to fossil stems, which was indeed pioneer work at the close of last century.

R. J. D. Graham.

4. Plant Physiology.

In the earliest publications of the Society the interest of the members, as shown by the printed records, was wide, and embraced all aspects of Botany more or less equally. No section of the science was left without some notice. The position of botanical science at the time of the initiation of the Society is evidenced by the presidential address delivered by Dr. Greville and printed in the first volume of the *Transactions*. The literature cited by Dr. Greville on that occasion shows twenty-six papers classed as "descriptive and critical"; twenty-one on "Floras"; fourteen as "illustrated works"; eighteen miscellaneous—chiefly on collecting and exploration; five on Vegetable Chemistry, and four on Physiology. Truly a wide cast of the net.

The predominance of "descriptive and critical" papers taken in conjunction with the high number of Floras and works dealing with collecting and exploration indicates that the Society commenced its life at the period when the "philosophic phase" of biological science was weakening and the glorious era of collection and identification of the world's plants was marching towards its fulfilment.

An interesting fact in this connection is that one of the

papers on plant physiology cited by Dr. Greville is the publication which describes Ward's case devised for the safe transit of living plants over long distances—the Wardian case of to-day. How much of the glory of our gardens and our wealth of knowledge is due to this change of phase and the men who made the expansion possible?

Turning now to a somewhat more detailed examination of the papers of physiological interest actually communicated to the Society we find that not only were the members reporting on physiological phenomena observed by themselves, but certain members were noting publications in other journals and drawing the attention of the Society to new knowledge of importance obtained elsewhere. Vol. i of the *Transactions* shows this, for we find a paper by Herbert Giraud directing attention to the nitrogen problem in the nutrition of plants and dealing at length with the work of Boussingault. That the Society was ever concerned with the general position of the nitrogen problem is evidenced right through the publications, for we find in 1896 the presidential address of A. P. Aitken entitled "The Nitrogenous Food of Plants," and again in 1897 we find a paper by William Somerville discussing experiments with Nitrogin, and in the same year a paper by R. Stewart MacDougall on the bacteria of the soil emphasising the nitrogen problem.

Other trends of the special interests of members of the Society will emerge later in this review, but in the meantime some of the individual papers may be noted.

In vol. i a paper dealing with the natural plant dyes used for colouring wool in the Shetland Islands is of interest, as is another on the mucilage in the bark of Tilia.

In vol. iii is published a paper by a young German scholar visiting Edinburgh, Dr. A. Voelcker, of Frankfort, Germany, and the same worker has a paper in vol. iv, but now he is described as of the Royal Agricultural College, Cirencester. The first paper dealt with the chemical composition of the fluid in the ascidia of *Nepenthes*, while the second reports on the analysis of the watery secretion of the leaves of Mesembryanthemum. These two papers, particularly the first, mark a point in the development of plant science in this country, for the young German visitor was to become the man who took a major part in the development of scientific

agriculture in Britain for many years, and whose work on the theory of manuring still stands. Other papers by Voelcker appear in later volumes, but none after vol. vi, by which time he had no doubt found a wider field of interest.

A paper of more than passing interest is that by Stevenson Macadam in vol. iv, dealing with the presence of iodine in various plants, with some remarks on its general distribution. The paper directs attention to the relationship between plant composition and the appearance of goitre in the human subject.

In 1885 Dr. Gilchrist discusses the relationship between the growth of rare alpines and the chemical composition of the rocks underlying them.

Other ecological papers still of interest are scattered throughout the earlier *Transactions*, such as those recording detailed observations made on plants after years of peculiar or extreme weather. As an example may be cited that by Dr. G. Dickie published in 1885, recording the damage done to plants in various situations in the Aberdeen district by a frost of the previous year. He notes amongst other things that all grafted plants were killed while members of the same species on their own roots survived. A long series of papers by the curator of the Royal Botanic Garden record the time of flowering of the different species in the Garden, and the various deviations are related to weather phenomena.

In 1856 an idea still fashionable was suggested in a paper by the Rev. J. Wardrop. He develops the idea of phylogenetic relationship being evidenced by chemical similarity of the species, and insists that the "naturalness" of a grouping based on morphological criteria may be checked by chemical methods.

On occasion a touch of humour enters into the otherwise sedate pronouncements of these earlier savants—possibly unconscious humour—as in a paper in 1857 dealing with analyses of certain newly received Australian wines. The report praises the quality of the samples but deplores their smallness! That the spirit of prophecy was also present is shown by the statement in this same paper that the cultivation of the vine and the manufacture of wine "will no doubt be carried on extensively in Australia."

W. Lauder Lindsay, M.D., in 1856 reports that a high

incidence of plant disease always seems to occur in India when a cholera epidemic breaks out, and suggests that the cholera patient exhales some influence detrimental to plants. The observation is of value if it is confirmed, though to-day identity of causation of cholera and plant disease in so far as environmental factors such as temperature and humidity are concerned would be looked for.

The question of electricity and the plant from time to time exercised the minds of the Fellows. The effects of lightning are mentioned many times, and insistence placed on the report that birch and beech trees seem to be immune to lightning, while other trees are killed. As early as 1856 H. F. Baxter reports the existence of electrical potential differences between different parts of living plants.

Another paper with a modern flavour is that read by Professor Balfour in 1857. The paper had been written by Professor Gregory just before his death, and discusses aspects of base exchange and adsorption in soil not far removed from the theories current to-day.

In the *Transactions* for 1859 we find proof that members of the Society were actively interested in practical problems in a paper summarising the technical evidence offered in a then recent law case on the effect of noxious gases on plants. Work on a somewhat related subject—the effect of anaesthetics on plants—is published from the pen of William Coldstream. Coldstream had been Prizeman in the Professor's class, and the report he submits consists of the essay which had gained him the special honour. He had experimented with the sensitive plant (*Mimosa pudica*), stamens of *Berberis* and *Helianthemum*, and the column of *Stylidium*.

An aspect of the Society's earlier publications which gives freshness and interest to-day was the publication of personal letters from members, and friends of members, overseas to members at home. Intimate touches on very diversified topics amongst the more formal papers lighten the subject-matter at many points. How valuable these communications may be is evidenced by a long series of letters from many correspondents all dealing with the introduction and establishment of cinchona into India. This series commences about 1864.

A number of papers of considerable interest to anyone

specially interested in water relations of plants occur in 1869 and 1870. The first is by Mr. McNab on results obtained from cutting and transplanting a plaited hornbeam hedge located in the Royal Botanic Garden. Another paper is by W. R. McNab, a son of the last-mentioned author, describing experiments on the transpiration of watery fluids by plants. This paper gives very detailed figures, and is of special interest in that the spectroscope was used to trace the various fluids in the plant. By means of spectroscopic analysis McNab provides thirty significant figures for water relationships, and includes such as the absorption of water from the atmosphere by the leaf and other figures usually ignored nowadays.

In vol. xi, 1871–1873, Sir John Don Wauchope, Bart., gives a detailed report of "bleeding" in a hornbeam tree. The term exudation pressure might be used to-day, but would be no more descriptive of the phenomenon reported. A branch of hornbeam, 1½ inches in girth, during nine hours exuded 1 gallon 3 gills of sap, and bled at about this rate for three days, when at last the branch was successfully plugged.

Physiological studies in seed germination commenced in about 1873, for in vol. xii, of 1876, an experiment with turnip seed by A. Stephen Wilson is reported, followed by a long paper in vol. xiii, 1879. The author was interested in the speed of germination and subsequent success of embryos and plants raised from large seeds as compared with the same from small seeds. This author digresses to allude to the then neglect of agricultural botany in favour of agricultural chemistry. In this regard he says: "Provided plenty of manure is put into soil the intimate laws and habits of seeds and plants to be grown may be ignored, the result will be proportional to the manure. Pap of all sorts has been manufactured regardless of cost; feeding-bottles of the most attractive design have been presented, but whether the child, Flora's little pale sprawling embryo, should have its head or its heels uppermost has mostly been regarded as immaterial." To such pioneers, it may be supposed, the present proud position of Agricultural Botany, with its seed-testing stations, its plant-breeding stations, and so on, must be ascribed.

Indeed the next paper on record to deal with seeds is one by A. N. MacAlpine, who in 1891 described an invention of his own designed specifically for the testing of agricultural

seeds. A. N. MacAlpine, later to become the Professor of Botany in the new West of Scotland College of Agriculture, did much to develop and foster the modern science of Agricultural Botany.

In 1893, 1894, and 1896 Mr. Cuthbert Day offered meticulous reports on detailed experiments regarding germination of barley and wheat.

In 1889 Professor I. Bayley Balfour devoted his presidential address to an exhaustive review of the literature dealing with chlorophyll.

Comparing the first President's address with this one some fifty years later we realise the change which had taken place in botanical study. The first President was able to review the work of the whole science easily within the compass of a short paper. The President of fifty years later devoted more space and time to a comparatively small portion of plant physiology.

In June 1891 appeared a paper describing the work of the Pilcomayo Expedition, written by the young naturalist who accompanied the party. The vegetation is described in general terms, and in a later paper formal descriptions of new species are submitted. It may be wondered whether Botany did not lose too much, to the great gain of her sister science Zoology, when J. Graham Kerr, the young man in question, elected to specialise on animals rather than plants.

With the advent of the twentieth century we see evidence of a further change of phase in the character of the publications. The description and elucidation of naturally occurring phenomena tend to give way to reports of deliberately planned laboratory experiments, with all the environmental factors controlled. Papers appear written by L. B. Stewart and R. J. D. Graham, working either separately or together, on propagation; papers by E. Philip Smith on plant pigments and propagation, and individual papers by other workers on subjects such as light reception by *Mesembryanthemum* and germination in seeds.

A. NELSON.

5. OTHER BRANCHES.

Arboriculture in its various aspects has occupied the attention of the Society continuously throughout the whole

period under review. During the century there have been numerous introductions of exotic trees and shrubs, and the histories of these with their behaviour in cultivation have been invariably recorded. At intervals there have been contributions of special note, as for example those by Lt.-Col. Barclay and Sir Robert Christison. The latter will be remembered for his precise and laborious researches resulting in a series of articles (1878–1881) on the "Exact Measurement of Trees and its Application," a distinct and unusual contribution to tree science.

Another notable contribution was that of our distinguished Fellow, J. E. T. Aitchison, who as a result of his work with the Afghan Delimitation Commission contributed in 1890 the valuable paper on the "Products of Western Afghanistan and of North-East Persia" which occupies over two hundred pages of vol. xviii of the *Transactions*.

Turning to Palaeobotany we find in the earlier contributions to the Society the influence of the numerous publications, about 1820, of Sternberg and Brongniart. The first paper on this subject appearing in the *Transactions* was by Robert Paterson, who in 1840 described *Pothocites Grantonii* from casts showing no internal structure. It is significant of the state of knowledge at the time that the fossil was then regarded as a "monocotyledonous inflorescence." It is also significant of the slow and cautious development of the science that this erroneous deduction remained uncorrected until 1885, when Kidston referred the fossil to *Archaeocalamites*. Paterson's effort was succeeded by a long series of notable contributions to palaeobotany by such eminent enthusiasts as J. H. Balfour, Carruthers, C. W. Peach, Dawson, Etheridge, Christison, Kidston, and Gordon; of whom the most prolific was C. W. Peach, regarded by his contemporaries as "one of the most active and zealous of palaeontologists." In more recent times palaeontology is poorly represented, since it is now dealt with mainly by geologists.

Such then, in brief outline, have been the main activities of the Society. It is hoped that this account may convey some idea of the work of past and present members, and of the trend of botanical investigation during the last hundred years. Throughout the century the Society has maintained its position in two ways: firstly through the original work and

personal investigations of its Fellows, and secondly through the communication of each important advance made outwith the Society to the Fellows by those of their number who had familiarised themselves with such new developments. For the future, what better can be hoped for than that the same spirit will keep the Society ever abreast of the scientific developments of its time?

LIST OF PRESIDENTS.

1836–1839	Prof. Robert Graham.
1839–1840	Robert K. Greville, LL.D.
1840–1841	David Falconar.
1841–1842	Prof. Robert Christison, M.D.
1842–1843	Patrick Neill, LL.D.
1843–1844	Prof. Robert Graham, M.D.
1844–1845	Andrew Douglas Maclagan, M.D.
1845–1846	Prof. John Hutton Balfour, M.D.
1846–1847	Robert K. Greville, LL.D.
1847–1848	Rev. Prof. John Fleming, D.D.
1848–1849	Prof. J. H. Balfour, M.D.
1849–1850	Rev. Prof. John Fleming, D.D.
1850–1851	Prof. J. H. Balfour, M.D.
1851–1852	William Seller, M.D.
1852–1855	Prof. J. H. Balfour, M.D.
1855–1856	Lt.-Col. Edward Madden.
1856–1857	Rev. Prof. John Fleming, D.D.
1857–1858	William Seller, M.D.
1858–1859	Andrew Murray, W.S.
1859–1860	Prof. George James Allman, M.D.
1860–1861	Wm. H. Lowe, M.D.
1861–1862	Thos. C. Archer.
1862–1863	Prof. Andrew Douglas Maclagan, M.D.
1863–1864	Prof. J. H. Balfour.
1864–1865	Alexander Dickson, M.D.
1865–1866	Robert K. Greville, LL.D.
1866–1867	Isaac Anderson-Henry.
1867–1868	Charles Jenner.
1868–1869	Hugh F. C. Cleghorn, M.D.
1869–1870	Sir Walter Elliot, K.S.I.
1870–1871	Alexander Buchan, M.A.
1871–1872	Prof. Wyville Thomson, LL.D.
1872–1873	James McNab.
1873–1877	Sir Robert Christison, Bart.
1877–1879	Thomas Alexander Goldie Balfour, M.D.
1879–1880	William Gorrie.
1880–1882	Prof. Isaac Bayley Balfour.
1882–1884	William B. Boyd.
1884–1887	Prof. Alexander Dickson.
1887–1889	William Craig.
1889–1891	Robert Lindsay.
1891–1893	David Christison, M.D.
1893–1895	Prof. Frederick Orpen Bower.
1895–1897	Andrew P. Aitken, D.Sc.
1897–1899	William Watson, M.D.
1899–1901	Rev. David Paul.
1901–1902	Col. Fred Bailey, R.E.
1902–1904	Prof. J. W. H. Trail.
1904–1906	Prof. I. B. Balfour.
1906–1908	J. Rutherford Hill, Ph.C.
1908–1910	T. Bennet Clark, C.A.
1910–1912	A. W. Borthwick, D.Sc.
1912–1913	Sir Archibald Buchan-Hepburn, Bart.
1913–1915	R. Stewart MacDougall, D.Sc.
1915–1917	R. A. Robertson, M.A., B.Sc.
1917–1920	James Whytock.
1920–1922	Wm. G. Smith, Ph.D.
1922–1925	Prof. Wm. Wright Smith.
1925–1927	Prof. J. Montagu Drummond.
1927–1929	Col. John Sutherland, C.B.E., LL.D.
1929–1931	J. Rutherford Hill, Ph.C.
1931–1933	William Young.
1933–1935	Malcolm Wilson, D.Sc.
1935–19	Prof. Sir Wm. Wright Smith.

Report of the Annual Conference of the Cryptogamic Section, 1936.

By Rupert Smith.

(Read 15th October 1936.)

The Fifty-fifth Annual Conference of the Cryptogamic Society, now a section of the Botanical Society of Edinburgh, was held at Callander on the 21st, 22nd, 23rd, and 24th September 1936, headquarters being at the Caledonian Hotel. Only five members were present, but they formed a good working quorum for examination and discussion in the evening of the material collected during the forays.

The afternoon of Monday 21st was spent in the Cragg Woods at the back of Callander and part of the Drummond estates. The upper part towards the Bracklinn Falls is much overrun with bracken, but a good variety of fungi was collected in the lower part which is mainly composed of a hard wood.

Tuesday 22nd was spent on the estate of Cumbusmore and in an oak wood in the vicinity of Callander.

The morning of Wednesday 23rd was cold and frosty, but as the day advanced a strong sun gave warmth and beauty to the highland scene by Loch Lubnaig and Strathyre, where the party went to foray the woods now belonging to the Forestry Commission. The ground, however, was not very suitable, being too dense with birch, whin, broom, heather, and bracken. After lunch the party divided, some going to the Trossachs and others to the banks by the Falls of Leny.

Thursday 24th was spent in the woods of Capt. Murray Buchanan of Leny. A forester conducted the party to a coniferous wood on the slope of a hill with a deep picturesque gully.

The weather throughout was favourable and Friday morning saw the end of an interesting and enjoyable conference.

As nearly all the fungi were found within a radius of two miles round Callander the actual woods are not mentioned in the list. Among the less common species were *Macropodia*

macropus and *Cordyceps ophioglossoides*, the latter parasitic on *Elaphomyces granulatus*.

The only business devolving on the meeting was the selection of a locality for 1937 and the appointment of secretary.

With the prospect of the Mycological Society coming to Scotland, it was decided to join with that Society. Should they not come, Elgin was selected.

Rupert Smith was re-elected secretary.

LIST OF SPECIES GATHERED DURING THE FORAY.

Hymenomycetes.

Amanita muscaria (Linn.) Fr.; spissa Fr.; mappa (Batsch) Fr.; rubescens (Pers.) Fr.

Amanitopsis vaginata (Bull.) Roze; fulva (Schaeff.) W. G. Sm.; nivalis (Grev.) Rea

Armillaria mellea (Vahl) Fr.; mucida (Schrad.) Fr.

Lepiota cristata (A. et S.) Fr.

Tricholoma albobrunneum (Pers.) Fr.; rutilans (Schaeff.) Fr.; terreum (Schaeff.) Fr.; columbetta Fr.

Clitocybe nebularis (Batsch) Fr.; clavipes (Pers.) Fr.; fragrans (Berk.) Fr.

Laccaria laccata (Scop.) B. et Br.; var. amethystina (Vaill.) B. et Br.

Mycena pura (Pers.) Fr.; ammoniaca Fr.; haematopus (Pers.) Fr.; capillaris (Berk.) Fr.

Omphalia umbellifera (Linn.) Fr. var. pallida Cooke; fibula (Bull.) Fr.; pseudoandrosacea (Bull.) Fr.; stellata Fr.

Pleurotus porrigens (Pers.) Fr.

Hygrophorus pratensis (Pers.) Fr. and var. cinereus Fr.; virgineus (Wulf.) Fr.; ceraceus (Wulf.) Fr.; miniatus Fr.; conicus (Scop.) Fr.; calyptraeformis Berk.; chlorophanus Fr.; psittacinus (Schaeff.) Fr.; laetus (Pers.) Fr.; unguinosus Fr.

Lactarius turpis (Weinm.) Fr.; vellereus Fr.; quietus Fr.; mitissimus Fr.; cimicarius (Batsch) Cke.

Russula nigricans (Bull.) Fr.; rosacea (Pers.) Fr.; cyanoxantha (Schaeff.) Fr.; fellea Fr.; drimeia Cke.; emetica (Schaeff.) Fr.; ochroleuca (Pers.) Fr.; atropurpurea

(Krombh.) Maire; Romellii Maire; graminicolor (Secr.) Quél.; delica Fr.

Cantharellus cibarius Fr.; tubaeformis Fr.

Marasmius peronatus (Bolt.) Fr.; hariolorum (DC.) Quél.; dryophilus (Bull.) Karst.

Androsaceus polyadelphus (Lasch.) Pat.

Entoloma jubatum Fr.

Nolanea pascua (Pers.) Fr.

Leptonia sericella (Fr.) Quél.

Clitopilus prunulus (Scop.) Fr.

Paxillus involutus (Batsch) Fr.

Pholiota spectabilis Fr.; subsquarrosa Fr.

Inocybe rimosa (Bull.) Fr.

Hebeloma crustuliniforme (Bull.) Fr.

Flammula carbonaria Fr.

Galera tenera (Schaeff.) Fr.; hypnorum (Schrank) Fr.

Cortinarius (Phlegmacium) multiformis Fr.; (Myxacium) elatior Fr.; (Inoloma) violaceus (Linn.) Fr.; alboviolaceus (Pers.) Fr.; (Dermocybe) caninus Fr.; anomalus Fr.; (Telamonia) armillatus Fr.; evernius Fr.; psammocephalus Fr.

Stropharia semiglobata (Batsch) Fr.; inuncta Fr. var. pallida B. et Br.

Hypholoma sublateritium (Schaeff.) Fr.; fasciculare (Huds.) Fr.; epixanthum Fr.; dispersum Fr.; velutinum (Pers.) Fr.; appendiculatum (Bull.) Fr.; lacrymabundum Fr.

Psilocybe semilanceata Fr.

Psathyrella gracilis Fr.

Anellaria separata (Linn.) Karst.

Panaeolus campanulatus (Linn.) Fr.

Coprinus atramentarius (Bull.) Fr.; micaceus (Bull.) Fr.; plicatilis (Curt.) Fr.

Gomphidius viscidus (Linn.) Fr.

Boletus elegans (Schum.) Fr.; badius Fr.; piperatus (Bull.) Fr.; chrysenteron (Bull.) Fr.; subtomentosus (Linn.) Fr.; edulis (Bull.) Fr.; luridus Fr.; scaber (Bull.) Fr.

Polyporus giganteus (Pers.) Fr.; betulinus (Bull.) Fr.; lacteus Fr.

Fomes annosus Fr.

Ganoderma applanatus (Pers.) Pat.

Poria vulgaris Fr.; sanguinolenta (A. et S.) Fr.

Polystictus versicolor (Linn.) Fr.; and var. nigricans Lasch.; and var. fuscatus Fr.
Irpex obliquus (Schrad.) Fr.
Daedalea quercina (Linn.) Fr.
Fistulina hepatica (Huds.) Fr.
Hydrum repandum (Linn.) Fr.
Grandinia granulosa Fr.
Stereum rugosum (Pers.) Fr.; hirsutum (Willd.) Fr.
Corticium arachnoideum Berk.; Sambuci (Pers.) Fr.
Clavaria fusiformis (Sow.) Fr.; rugosa (Bull.) Fr.; vermicularis Fr.; fragilis (Holmsk.) Fr.
Calocera viscosa (Pers.) Fr.

Gasteromycetes.

Phallus impudicus (Linn.) Pers.
Lycoperdon echinatum Pers.; perlatum Pers.
Scleroderma aurantium Pers.; verrucosum (Vaill.) Pers.

Uredinales.

Coleosporium Tussilaginis (Pers.) Kleb.
Melampsoridium betulinum (Pers.) Kleb.

Plectascales.

Elaphomyces granulatus Fr.

Pyrenomycetes.

Cordyceps ophioglossoides (Ehrh.) Link
Xylaria Hypoxylon (Linn.) Grev.
Rhopographus filicinus (Fr.) Nits.
Nectria cinnabarina (Tode.) Fr.
Sphaerotheca pannosa (Wallr.) Lév.

Discomycetes.

Macropodia macropus (Pers.) Fuck.
Coryne sarcoides (Jacq.) Tul.
Bulgaria inquinans (Pers.) Fr.
Trichoscypha calycina (Schum.) Boud.
Lachnea stercorea (Pers.) Gill.
Rhytisma acerinum (Pers.) Fr.

PROTOMYCETACEAE.

Protomyces macrosporus *Unger*

DEUTEROMYCETES.

Oidium alphitoides Griff. et Maubl.
Ovularia obliqua (Cooke) Oud.
Isaria farinosa (Holmsk.) Fr
Cytospora *ambiens Sacc.*

The Scottish Alpine Botanical Club Excursion, 1935. By Robert Moyes Adam, F.L.S. (With Pls. IV–VI.)

(Read 15th October 1936.)

The summer meeting of the Club was held at Boat of Garten in Strathspey. The elevation of the valley there is about 700 feet, the annual rainfall for the district being some 30 inches, while the soil, composed largely of gravels and sand, is extremely porous.

The district has always been noted for its woods and the quality of the timber produced, and the presence here and there of neatly constructed homesteads of locally produced timber, and the smell of wood-fuel, bring to mind the charms of a Norwegian valley. Native Scots Pine has been the chief feature, but private enterprise has contributed largely to the establishment of valuable forest. Not far from Boat of Garten a stand of maturing Scots Pine can be seen which was self sown on the site of a former wood felled over sixty years ago. Regeneration of this character is not possible in these days unless effective measures are taken to fence the area. Where this has been tried in Rothiemurchus, a few miles away, successful plantations have been formed of first-rate Scots Pine. Some disastrous fires have destroyed several fine stretches of natural Pine forest, and one of these was seen near Loch Garten. Some examples of unscientific felling were seen in the area near Glen More, and though twenty years have passed it is still wellnigh impossible to make a passage through this area on account of the debris strewn in every direction.

In recent years interest has centred in this part of Strathspey by the national scheme for afforestation. Since the war the State has acquired a considerable area in the district, and there is already every prospect of a landscape even more gloriously wooded than at present. It is also interesting to record that in future the forests of Glen More are to be known as the Queen's Forest in honour of Her Majesty Queen Mary's Silver

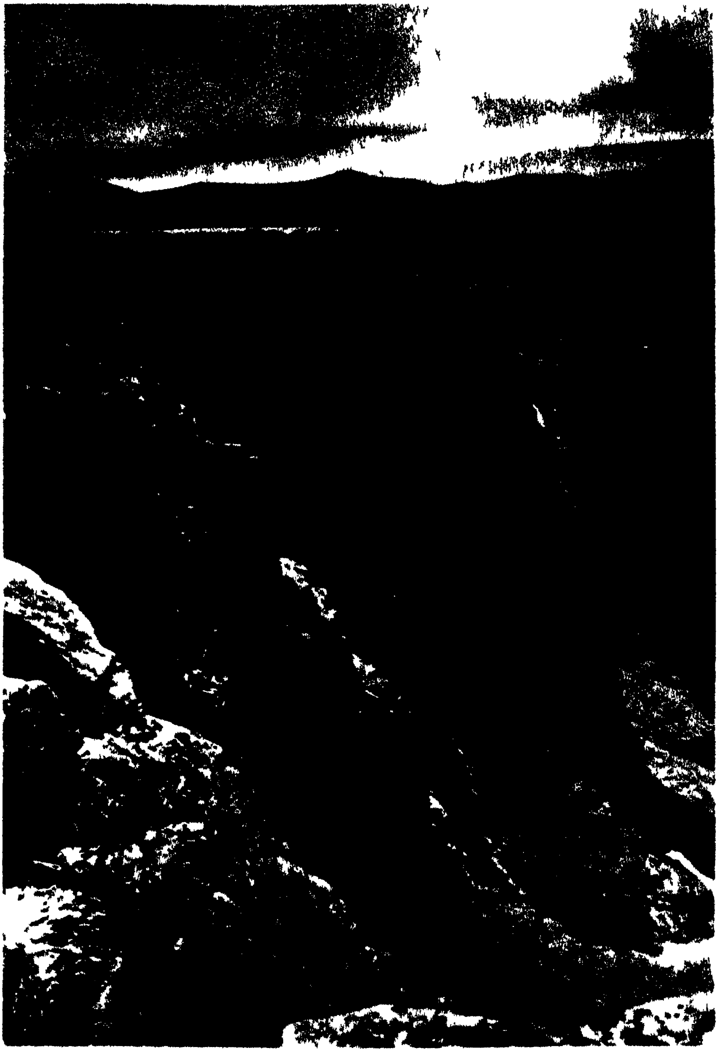
Jubilee. Tree-planting operations are in full swing, and during the visit much evidence was observed of this excellent work.

On the 16th July the Club party arrived at Boat of Garten Hotel, and the corry and summit of Cairn Lochain was selected for the first day's objective. The mountain is one of the range of peaks which extends from Cairngorm to the Larig Pass. All are intimately linked and vary in height from 4000 feet at the eastern extremity to 3750 feet at the point where they reach the Larig. On this north-west side are a series of steep corries which form conspicuous landmarks when seen from Aviemore, so with the prospects of an interesting day the Club party set out on the morning of the 17th.

Proceeding by the wooden bridge that spans the Spey at the "Boat" the road was taken which leads to Coylum and Glen Sluggan. From the top of the Sluggan Pass the road descends rapidly, passing through both old and new forest; then for a mile stretches a rather desolate moorland tract, until the environs of Loch Morlich are approached. After a halt at Ben More Lodge, the walk was resumed by way of a wooden bridge over the Allt Mor and along a well-marked path leading through the forest.

Below the old Pines masses of the two Vacciniums, *V. Myrtillus* and *V. Vitis-idaea* grew everywhere. In Strathspey it is a regular custom, so it was said, for the people to collect the fruits of *V. Vitis-idaea*. Certainly few districts can have a greater abundance of this plant, which is best after a forest is felled, and plants under such conditions seem to produce phenomenal fruit crops. *Linnaea borealis* and *Pyrola uniflora* have been recorded from the woods of Glen More but neither was found, though some *Pyrola secundiflora* was seen near the Ryvoam Pass. An interesting feature was the presence of numerous old ant-hills which were being colonised by *Vaccinium Vitis-idaea*.

Near the tree limit the path divides, the upward course which ultimately leads to the summit of Cairngorm forming one fork, while the other, which made for the Allt Mor stream, was the one which served best for the approach to Corry Lochain. Not much was noted except by the stream, and there a fine form of *Campanula rotundifolia* var. *latifolia* was growing on some gravel. Cloudberry foliage was abundant in the heather. The presence of *Cornus suecica* with occasional



The precipices of Cairn Lochan. Rocks composed of granite, with a north-west exposure.

R. M. Adam.

flowers recalled this plant's habit of changing its straw-coloured inflorescence bracts into green when the fruiting stage is reached.

Gradually the moorland gave way to drier and more stony conditions, and all signs of peat moor vanished as the party approached the threshold of the corries. Another stream had to be forded, this being the one which comes from Coire Sneachda. After this, boulders and granite blocks increased in quantity, giving an aspect of bareness to the place. Here the soil is shallow with much gravel, and what plant life existed looked bleached and lifeless. Where Heath grew it seemed closely cropped, the extremities of the shoots being quite grey. There were numerous plants of *Loiseluria*, forming mats of varying extent. In the heart of the corry lies a tiny lochan whose waters reflected a strange green colour. It apparently had no outlet, but the emergence of a series of underground watercourses lower down the corry explained this.

The cliffs of Corry Lochain form a great amphitheatre. They commence from the edge of the lochan as a steep slope partly of scree and soil, and at a higher level change to slabs of granite pitched at a high angle. Immediately above rises the perpendicular face of the mountain. From below, the plant life visible was meagre, and a rather dry and barren corry might have been expected. Closer acquaintance, however, reversed this impression. Access to the best ledges was gained by a long climb over scree, several terraces of soil being found between the perpendicular face and the slabs. Vegetation was almost luxuriant and a most interesting time was spent. The altitude was about 3500 feet, and it was noted that plant life was most abundant on those ledges which received the late afternoon sun. The most conspicuous plant was *Ranunculus acris*, which made a splendid show among the grass of the ledges. *Saxifraga rivularis* was in all stages of flower and fruit, and *Veronica alpina* was also noticeable. Clinging to cracks in the great granite wall were lovely specimens of *Cerastium arcticum*, and in damper crannies *Cochlearia alpina* and *Saussurea alpina* were seen in lesser quantity along with large forms of *Taraxacum*. *Saxifraga stellaris* was plentiful and confirmed a previous observation that the Cairngorm forms are larger and finer than those from other

hill stations. Snow still lay in a few of the innermost gullies, and deposits of soil and gravel on all the ledges suggested recently melted snow.

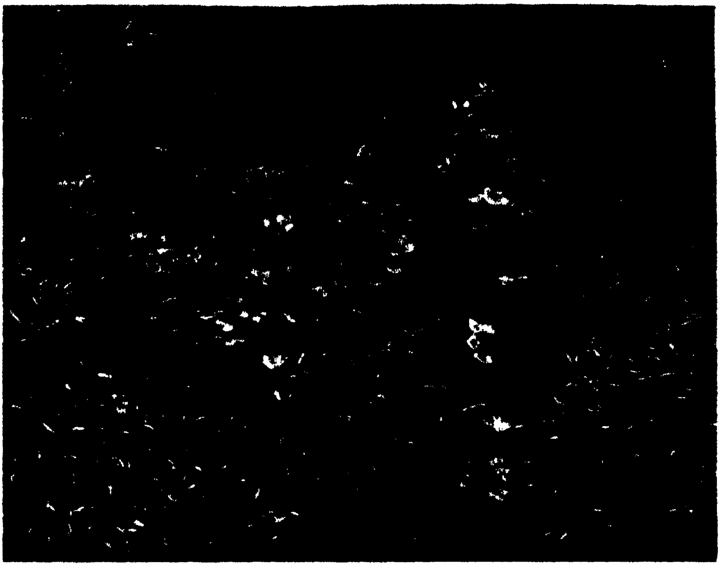
On leaving the corry the party divided, some to descend to lower levels, while the others set off up a slope of broken rock towards the summit. On the way up flowering specimens of *Silene acaulis* and *Juncus trifidus* were seen, and just on the crest *Luzula arcuata* was found.

The view from the top of Cairn Lochain, while like that from the well-known Cairngorm, is made more impressive by the yawning precipices that fall sharply down to the north. Some haze in the west obscured the Monadhliadh Hills, but to the far north Sutherland and Caithness could be distinctly seen over the distant waters of the Moray Firth. Most impressive also was the view of Sgoran Dubh and the entrance to Glen Enich. At length satisfied that every peak had been named, steps were turned westward. On the descent a few water-flushes were visited and *Euphrasia frigida* collected, and the party ultimately reached the hotel about 8.30 p.m.

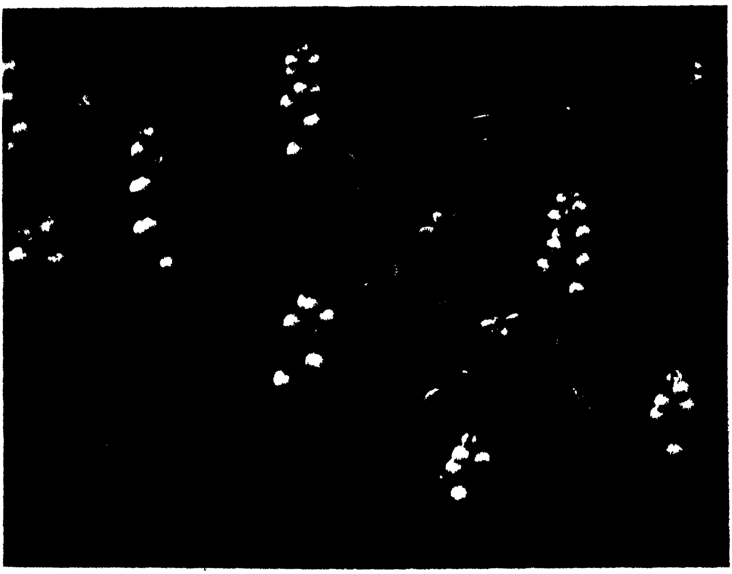
The following morning, cars were again employed to convey the party to Loch Pityoulish, rather a pretty loch set amid great heaps of moraine and a mile south of Glen Sluggan. The shores were found to hold some dense beds of *Phragmites* and other aquatic vegetation on the western margin. Some dragging was also done, resulting in *Isoetes* and some *Potamogetons* being seen.

From Pityoulish the party proceeded to Glen Enich. The old forest at the entrance to the Glen was hunted, and a wet bog with some open water was searched. *Pyrola media* was seen in very fine state among the heather where the forest had been felled. After an interval for lunch the party divided, the more energetic section going ahead, while the others stayed to make a more intensive search of the way-side. The road up Glen Enich provided another glimpse of real old forest. In parts the Scots Pines are small and unhealthy, while at other places there are specially fine specimens. The undergrowth is Heath and Cotton Grass and indicates a boggy state of soil. Above the forest grassy slopes and drier ground replace the moorland type, and that continues to Loch Enich.

This loch is an extremely lonely one and lies about 1200 feet up. Hemmed in by the great slopes of Braereach on the east

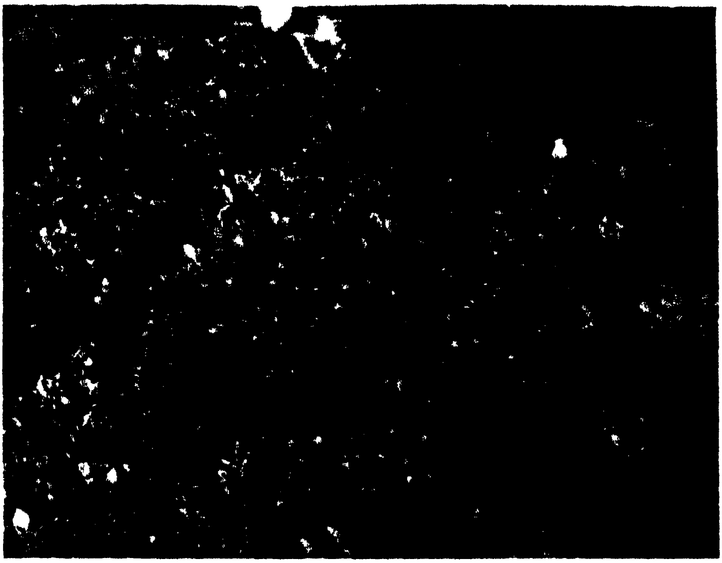


Saxifraga rivularis flowering on damp ledge at 3300 feet on Cairn Lochan.



Pyrola media growing among heather below Scots Pine trees, near Boat of Garten.

R. M. Adam.



Menziesia coerulea. Plant showing solitary flower at Sow of Atholl habitat.

Goodyera repens. Flowering plants in Strathspey Pine wood.

R. M. ADAM.

and Sgoran Dubh on the west, it presents rather a grim scene. *Caltha radicans* was picked at a boggy part of margin of the loch, though it mostly presents a stony shore with bleached sand in places. The hill-sides are dry except at the western end of the loch, where a stream forms a good hunting-ground. The ridges of Sgoran Dubh are dry and offer scope only to a cragsman.

In the evening, with the certainty of seeing *Linnaea borealis*, a run was made by Dulnan and Duthil to Loch in Dorb, where a very fine patch of the plant was seen. Flowers were mainly over, but sufficient remained to impress those members of the Club who had not seen much of it in Scotland.

The quest after *Menziesia coerulea* began next morning. Cars were taken to within a mile of Dalnaspidal, thereafter the party walked to the base of the nameless hill between Coire Domhain on the north and Coire Lindhearnaidh. This summit is sometimes called the Sow of Atholl, but no authority is known for the name. The hill is steep and has dense *Calluna* over most of its eastern side. Towards the top a series of screes sear the mountain and the vegetation becomes a mixture of *Vaccinium Myrtillus* and Heath.

Towards the Loch Garry end the *Menziesia* grows, and without minute directions is difficult to locate. Only three plants were seen and only one flower in a perfect state, which seems to indicate that it may die out. It was noted that the remaining plants are above the usual heather-burning level. It is fortunate that among *Empetrum*, *Erica*, and *Vaccinium* the plants are well concealed, and hope is expressed that all who visit the *Menziesia* will refrain from injuring them.

On the return journey to Boat of Garten the ruins of Ruthven Castle were visited. So ended a happy and successful meeting.

OBITUARY NOTICE.

LEONARD RODWAY.

Mr. Leonard Rodway, C.M.G. (who rendered outstanding services to Tasmania, Tasmanian and world botany), died during his eighty-third year on 9th March 1936.

After leaving school Rodway joined the training-ship *Worcester* and, passing all his examinations, proceeded to a career in the British Mercantile Marine. A severe illness, however, necessitated his retiral from this service and, seeking a congenial climate, he settled in Tasmania after a short sojourn in Queensland. By profession a dental surgeon, Rodway developed in his spare time a love of Botany, and many papers of high research quality resulted. In 1903 "The Tasmanian Flora" appeared, followed later by the "Wild Flowers of Tasmania." Rodway's interests, as shown by his publications, ranged from studies on the Tasmanian Mosses to the systematics of the Eucalypts. So wide and authoritative was Rodway's knowledge of the Tasmanian flora that Sir Edward Boscaddon appointed him Honorary Government Botanist, a post he held for over thirty years.

Despite Rodway's preoccupation with his profession as dental surgeon and Botany, he found time to do a considerable amount of work of a public nature on such bodies as the National Park Board, the Tasmanian Fisheries Board, the Committee of Management of the Hobart Botanic Garden, etc. In 1917 Rodway was awarded the honour of C.M.G. In 1905 Rodway was elected a Corresponding Member of the Botanical Society of Edinburgh.

In a speech Archdeacon Blackwood of Hobart said: "They respected his memory as a man, as a citizen, and as a scientist who had given of his best in the study and development of the beautiful things in nature. It was work well and truly done, and in doing it he had learned full appreciation of the values of truth, beauty, and goodness.

Those of us who knew Leonard Rodway can endorse the Archdeacon's words and add our own grateful remembrance of his friendly helpfulness, kindly grace, and unassuming authority in things botanical.

A. N.

TRANSACTIONS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CI

A Note on the Association of a Species of Phytophthora with a "Die-Back" Disease of the Raspberry. By J. M. Waterston, B.Sc. (With Pls. VII, VIII.)

(Read 17th December 1936.)

Introduction.

A die-back disease of the *Lloyd George* raspberry has been recognised locally in Scotland for the last five years. The disease is characterised by the death of the young shoots which curl downwards in a shepherd's crook, pointing usually outwards. The buds on canes from the previous year may fail to develop, or in cases of slight infection flowers may be formed which fail to set fruit. The whole stool becomes unhealthy and eventually dies, although in mild cases of infection recovery is known to take place towards the latter part of the season (Pl. VII). In the field the disease is restricted either to a few rows or to small localised patches sometimes in hollows in the ground, suggesting excessive soil moisture as a predisposing factor for infection.

An examination of the root system discloses that extensive root formation is generally lacking. The young roots usually show a definite die-back from their tips, and more rarely intercalary zones of infection. The diseased tissue exhibits

a brown discoloration which contrasts markedly with the normal white of the healthy root.

In the medium-sized roots that have died the cortex tends to crack and to peel off. If the root is not yet dead but dying, as it usually does from the tip, oospores may be regularly found. These possess the structure of typical resting spores with a yellow outer shell and a phycomycetous oospore contained in an elliptical oogonium. They are found distributed just beyond the layer of cortical cells lying immediately outside the endodermis, which Van Tieghem (1887) described as "*reseau sus-endodermique*" (Pl. VIII, fig. 1). Oospores have also been found in the cortex of young shoots suffering from die-back in the portions below ground level (Pl. VIII, fig. 2). An examination of forty *Lloyd George* raspberry stools from various localities at Edinburgh, Bo'ness, Peebles, and Hamilton in Scotland, and from Kent in England, showed that oospores were present in the roots of both healthy and diseased plants. There was, however, a significant increase in the frequency of their occurrence in the diseased stools. No oospores were observed in the roots of the wild raspberry.

The disease closely resembles Black root rot, described by Harris (1931). This is a die-back disease of raspberries which mainly affects the *Lloyd George* variety and is found widely distributed in Cheshire, Hampshire, East Sussex and Kent. The symptoms are a failure of bud development and an early withering of the laterals, resulting in the death of the canes. The roots of the affected stools show a rotting of the crown tissue often extending to the whole stool, but partially affected stools may recover later in the year. The affected plantations were observed to have heavy wet types of soil which retarded the normal production of root fibres. Symptoms similar to those observed in the field were induced on plants in pots by water-logging them, and Harris concluded that the predisposing factor of this disease was a water-logged soil. There is a great similarity between the symptoms of Black root rot die-back and the die-back associated with the phycomycetous oospores. A close relationship is suggested, since oospores have been obtained from both healthy and diseased raspberries from Kent, an area where Black root rot is known to occur.

Materials and Methods.

When the external symptoms of the disease are first noticed in the field the root system does not present very suitable material for the isolation of the primary invading fungus, as the root rot is usually in an advanced stage. Specimens received from the field have their rootlets dead and shrivelled, and it is only those stools showing a mild attack which give the best material for obtaining the fungus in an active state of growth.

Attempts at isolation of the causal fungus yielded species of *Pythium*, *Podospora*, *Fusarium* and *Botrytis*, none of which proved pathogenic on inoculation. It was concluded that these fungi were the normali nhabitants of vegetable mould.

Small pieces of diseased root, when washed free from soil and placed in Petri dishes containing tap water, gave rise to sporangia of the *Phytophthora* type. These were not formed when the roots were sterilised with hypochlorite according to the method of Wilson (1915), which was unfortunate, since all kinds of fast-growing soil fungi, ever ready to attack decaying roots, appeared in the attempted isolations.

Experiments were made in growing raspberries under conditions in which the normal soil fungi might be excluded by using partially sterilised soil and water cultures.

Healthy raspberry canes were obtained from a nursery in Edinburgh and planted in pots of soil obtained from patches of diseased stools from Hamilton in the Clyde Valley. Controls were similarly set up using soil which had been partially sterilised in a shovel over a furnace. One month later an examination showed that most of the pots had a few roots exhibiting a brown discoloration passing back from the tip. The difference in the number of infected roots between the controls and the unsterilised soil was significant enough to show that the disease was soil borne. The slight infection of the controls was explained when the nursery at Edinburgh was visited and it was found that a mild attack of the fungus was present on the "healthy" canes.

In the water culture experiment two raspberry stools were selected which showed a very slight infection, and these were washed free from soil. One stool had only one of its roots infected, and from the other all roots showing infection were

carefully removed. They were then transferred to water cultures which were kept continuously aerated and well illuminated. In three weeks the discoloration in the stool with the one infected root had passed through the whole root system, the fungus leaving a trail of oospores in its path. The control remained healthy. The water culture used had the following composition:—

Calcium Nitrate . . .	1·0 grm.
Potassium Chloride . .	0·5 grm.
Magnesium Sulphate . .	0·5 grm.
Calcium Phosphate . .	0·5 grm.
Water	1000 c.cs.

The Phycomycetes readily produce sporangia in mineral solutions, especially when the latter are kept well aerated and illuminated, so that water cultures provide a very favourable means of infection. The objection may be raised that the raspberry is not a water plant, and is therefore growing under abnormal conditions. The dying raspberry roots do not shrivel up as they do in the field, since they are completely immersed in water. Allowing for these differences of conditions in water culture and in the soil it is still possible to obtain a fair impression of the pathogenicity of the invading fungus.

Morphology of the Phytophthora sp.

Asexual Reproduction.

Dying roots, which when teased out showed oospores present in the tissues of the cortex, were washed free from soil and placed in tap water at room temperature (18° C.). These gave rise to a *Phytophthora* type of sporangium in less than twelve hours (Pl. VIII, fig. 3). The sporangia were found to arise terminally on a simple sporangiophore, developing in succession from below the base of a preceding sporangium, never passing through the empty sporangium as in the group of *P. cryptogea* (Pethybridge and Lafferty); they were markedly papillate, approaching the type seen in *P. cactorum* (Leb. and Cohn) Schroet. (text-fig. 1).

Measurements of fifty sporangia, fixed and mounted in gelatine, gave the following constants:—

Mean length . .	43·02 μ
Mean breadth . .	39·07 μ
Ratio b/l . . .	0·91

The zoospores are differentiated inside the sporangium and are liberated in a vesicle of very short duration (Pl. VIII, fig. 4). The time taken on one occasion was observed to be fifteen

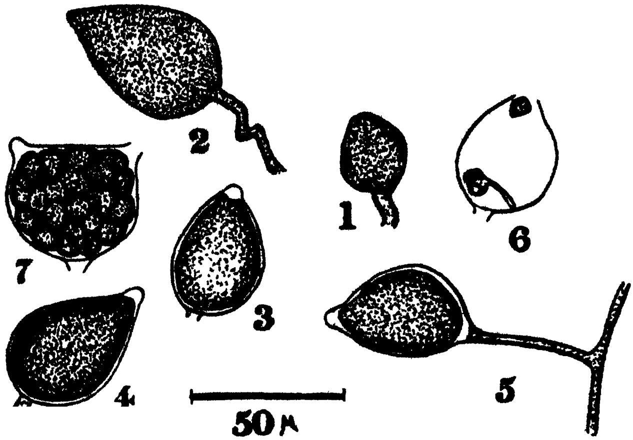


FIG. 1.—Variation in the *Phytophthora* type of sporangia obtained from infected raspberry roots. Nos. 1 and 2 are immature. Nos. 3–5 show the prominent papilla. No. 6 represents a sporangium with two trapped zoospores, one which has produced a germ tube. (See also Plate VIII, fig. 4.) No. 7 is a bicornuate type showing differentiation of the zoospores.

seconds. This distinguished the sporangium as a *Phytophthora* type distinct from the *Pythium* type of sporangium, where the contents flow into the vesicle before the zoospores are formed.

The presence of a marked papilla suggested an association with *P. cactorum* (Leb. and Cohn) Schroet., and characters similar to those of *P. cactorum* var. *applanata* Chester were found both in the firm attachment of the sporangia to the sporangiophore, which resisted detachment when shaken, and in the papilla, which was not dissolved or rendered invisible in lacto-phenol preparations. Evidence obtained from a study of the oospores gave further indication of an alliance of this fungus on morphological grounds with the *Phytophthora* species of the *cactorum-omnivora* group.

Single sporangia were teased out from diseased roots kept in water and placed in hanging drops of various nutrient media and tap water. In no instance was any further development of the sporangia or their contents observed, even when a quantity of hyphae was left attached.

Sexual Reproduction.

No antheridium has been observed in connection with the oospores in the host tissue. Had the antheridium been amphigynous one would expect traces of it to have remained visible in the region of the oogonial stalk. Absence of such

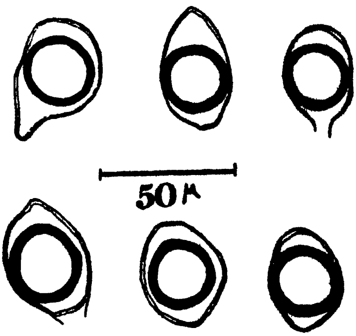


FIG. 2.—A selection of oogonia and oospores from infected raspberry roots.

evidence suggests a paragynous type of antheridium. According to Tucker (1931) a majority of paragynous antheridia is found only in *P. cactorum* and *P. syringae*. Chester (1932) has found that his var. *applanata* also resembles *P. cactorum* in this character.

The oogonia vary in shape from broadly clavate to subspherical, and the oospores are spherical, hyaline to light yellow in colour (text-fig. 2). Measurements of the oospores were made from teased root preparations, from four different localities:

1. England . .	(i) East Malling, Kent.
2. Scotland . .	(ii) Edinburgh.
	(iii) Bo'ness.
	(iv) Hamilton, Clyde Valley.

The frequency array for each locality is shown in Table I.

TABLE I.—FREQUENCY ARRAY OF OOSPORES IN RELATION TO DIAMETER.

Class Centre in μ.	Locality.				Aggregate.
	Hamilton.	Bo'ness.	Edin-burgh.	East Malling.	
19·5	2	2	1	1	6
20·5	1	6	2	2	11
21·5	11	4	4	6	25
22·5	17	18	9	16	60
23·5	16	17	24	23	80
24·5	27	27	29	17	100
25·5	19	20	15	19	73
26·5	5	5	12	14	36
27·5	1	1	3	1	6
28·5	1	..	1	1	3
	100	100	100	100	400

Since the oospores in the diseased roots from all four localities appeared to be uniform it was inferred that the same fungus was present in each case. This surmise proved correct on a statistical analysis of the oospores.

The significance of the differences between the means of the four samples of oospores was determined from the data in Table II.

TABLE II.

Locality.	Number Measured.	Mean Diameter.	Standard Deviation.	Standard Error of Mean.	Square of Standard Error of Mean.
East Malling	100	24·18 μ	1·671	0·1671	0·02793
Edinburgh	100	24·35 μ	1·576	0·1576	0·02484
Bo'ness	100	23·84 μ	1·697	0·1697	0·02880
Hamilton	100	23·89 μ	1·636	0·1636	0·02677

The standard error of the difference between the means of any two oospore samples was obtained by adding together the squares of the standard errors of their means and taking the square root of the sum. Any difference between means which is not at least three times this can easily be due to the error of sampling, and is not regarded as significant of a real difference in the populations sampled. In no case where the oospores from two different localities were compared was a significant difference obtained, so that the oospores from all four localities could therefore be regarded as samples from the same population. They were treated accordingly and the frequency array for the aggregate of four hundred oospores constructed. The constants obtained are compared with those obtained by Chester (1932) for the *Phytophthora* species on *Syringa* in Table III.

TABLE III.

	Raspberry *Phytophthora.*	*P. cactorum.*	*P. cactorum applanata.*	*P. syringae.*
Mean .	24·07 μ	22·94 μ	24·97 μ	31·10 μ
Median .	23·68 μ	22·79 μ	24·92 μ	31·68 μ
Mode .	24·50 μ	21·36 μ	24·92 μ	32·04 μ

In each case these figures were obtained from the measurement of four hundred oospores.

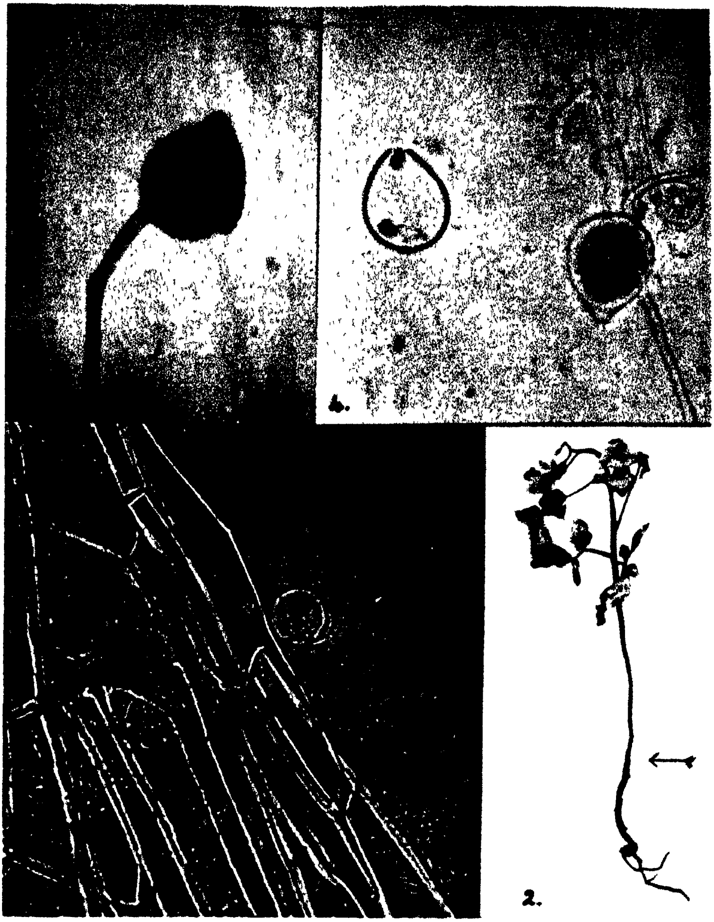
This analysis of the oospores in the raspberry root, together with a consideration of the rest of the morphological evidence, would indicate a relation of the fungus to the *Phytophthora cactorum-omnivora* group.

DISCUSSION.

The procedure on infected plantations is to collect and burn all diseased stools, which are replaced by new canes. This is frequently accompanied by a reappearance of the disease on the supplies, due partly to the accumulation in the soil of diseased root fragments rich in oospores which remain potential sources of infection, and to the planting of stock already infected.

A general view of a diseased row of *Lloyd George* raspberries showing symptoms of die back, contrasted with healthy rows in the background. Hamilton, Clyde Valley, August 1933.

J. M. Waterston.



t.w. oog. oosp. l.w.

FIG. 1. Tangential view of "*le reseau sus-endodermique*" of a rotted raspberry root showing part of the network of rectangular meshes formed by the longitudinal (l.w.) and transverse cords (t.w.) in which are embedded three oogonia (oog.) each containing a single oospore (oosp.). (×400.)

FIG. 2. Young raspberry shoot infected with *Phytophthora*. Oospores found in the cortex up to the level indicated by the arrow.

FIG. 3. A living sporangium obtained from a diseased root after twelve hours in tap water, showing the papilla. (×400.)

FIG. 4. A fixed sporangium with two trapped zoospores, the lower one of which has produced a germ tube. The other sporangium has not discharged its contents, and shows the prominent papilla. (×300.)

J. M. WATERSTON.

The restriction of the disease in the field to localised patches suggests that some predisposing soil factor such as excessive moisture exists. Only a few roots will succumb to fungal infection in a well-aerated soil of normal water content, but when conditions become unfavourable for vigorous root development it is to be expected that the resistance of the host to infection will be lowered.

Although the species of *Phytophthora* described has so far defied isolation and satisfactory proof of its pathogenicity is accordingly lacking, the writer feels justified in holding the opinion that the fungus is a primary parasite, which under conditions unfavourable to the host plant may assist the invasion of secondary organisms. The problem requires further study which the writer, as a result of other duties, has been unable to carry out.

Summary.

The association of a species of *Phytophthora* belonging to the *cactorum-omnivora* group with a die-back disease of the *Lloyd George* raspberry is recorded. The fungus appears to be widely distributed in Britain, becoming parasitic only under certain predisposing soil conditions.

The writer acknowledges his indebtedness to Mrs. N. L. Alcock, who first observed the disease, for material and valuable assistance; to Dr. Malcolm Wilson, Mycology Department, University of Edinburgh, where the investigation was carried out; and to the Director of the Imperial Institute of Mycology, for much helpful advice.

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Nodal Anatomy of Some Common Trees.

By Edith Philip Smith, B.A., Ph.D.

(Read 18th March 1937.)

In presenting these preliminary studies on the nodal anatomy of some common trees four markedly contrasting types have been chosen, namely: *Quercus*, with spiral phyllotaxis and a dissected stele; *Platanus*, with distichous phyllotaxis and a dissected stele; *Acer*, decussate phyllotaxis and a highly dissected stele; *Tilia*, distichous phyllotaxis and a continuous stele. It will be shown that the nodal structure is different in each case, especially in regard to the relative size and persistence of the median and lateral leaf-traces, and the relation of leaf gaps and rays. They will be discussed in detail below.

The material studied was collected in the first week in June. Fixation was in Bles' Fluid (Chamberlain (2)). Serial sections were cut in paraffin at 10 μ, and stained with either Safranin and Anilin Blue in Clove Oil (Chamberlain (2)), or Mallory's Ferric Alum Haematoxylin (McClung (9)). A series of drawings of transverse sections were made with the micro-projector, and from these the nodal plans were constructed.

NODAL STRUCTURE OF QUERCUS.

General Structure of the Foliage Twig.

The young leafy shoots of *Quercus* are a warm grey in colour, with a five-angled outline. The leaves, which are practically sessile, are inserted by slightly expanded bases on the ridges of the stem. The ridges are most prominent immediately under the node and gradually decrease downwards.

Phyllotaxis.

The phyllotaxis of the Oak is spiral, and is commonly described as a 2/5 spiral; that is, every sixth leaf is in vertical alignment with another, and the spiral connecting leaf 1 with leaf 6 winds twice round the stem.

Later growth-twists of the internode may obscure the pattern in an older twig, but the situation may be summed

up by saying that five leaves make a pattern, which is indefinitely repeated in the length of the shoot, and which is impressed on the stelar structure of both node and internode.

Vascular Structure. I. *Internodal.*

The stele of *Quercus* is dissected. A transverse section of a young twig shows a five-lobed stelar outline and a five-lobed pith (fig. 1). Taking the largest lobe as 1 and counting clockwise, they are arranged in order of decreasing size as follows: 1, 3, 5, 2, 4. As will be seen below, the stelar lobes consist mainly of median leaf-traces, so that the sizes of the lobes correspond to the proximity of their related leaves.

II. *Nodal.*

The entire primary stele is made up of common segments. Serial sections cut through twelve successive nodes of a young twig of *Quercus* confirm the statement made above that *five leaves* constitute a pattern which is repeated throughout the length of the twig.

In the description below the leaf of origin will be called leaf 1, and the ridge upon which it is inserted will be called ridge 1, the other ridges and corresponding stelar lobes being numbered clockwise. Leaf 6 is the beginning of a new leaf pattern.

The bud is inserted symmetrically on its corresponding ridge. In section it is seen that the bud gap appears in the middle of stelar lobe 1. At the node the whole stem increases in transverse diameter, and the stele also enlarges. The main stele reaches its greatest expansion just before the insertion of the bud-ring. The bud-ring opens on the adaxial side, makes contact with the edges of the gap, and without much contraction opens again on the abaxial side to give the median leaf gap (figs. 1 and 2).

There are three leaf-trace contributions and three corresponding gaps at each node (figs. 1 and 2). This corresponds to the trilacunar types of node described by Sinnott (10) as the commonest and most ancient type of node in the angiosperm. The median trace, which consists of five bundles and is much larger than the lateral traces, enters a wide gap which has opened at the middle of its corresponding stelar

ridge (reinforced as mentioned above by the bud ring) (fig. 1). The median trace runs through two internodes as a whole, then the right lateral third of the trace tapers off against its nearest lateral trace from a higher leaf, while the remaining

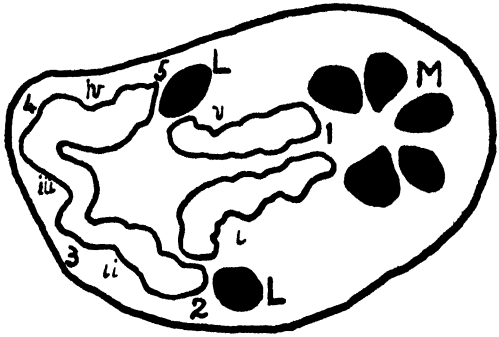

FIG. 1.—T.S. node of *Quercus*, showing entry of leaf-traces. ×20.
M = median trace, composed of five bundles.
L = lateral trace, composed of a single bundle.

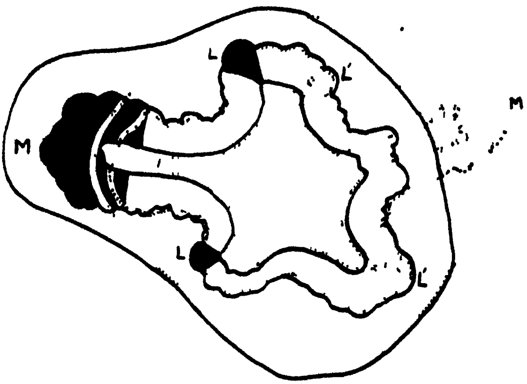

FIG. 2.—Tracing of two successive nodes of *Quercus*, superposed to show the relations of the stolar lobes and furrows with the leaf-traces. The stele is shown at the stage of greatest expansion, immediately after the entry of the leaf traces. M, L = median and lateral traces, leaf 1; M′, L′, same from leaf 2. ×20.

2/3 of the median trace soon splits again. The left third tapers off first, at the level of the third node below the node of origin, while the remaining middle-median portion tapers off to the left of the bud gap immediately below its leaf of origin (leaf 6). That is, the median contribution as a whole persists through *one repeat* of the leaf pattern only (see nodal plan, fig. 3).

The lateral leaf gaps appear at the sides of ridges 2 and 5; that is, the two ridges which are nearest the median trace (figs. 1 and 2). The gaps open towards the bud. Each lateral trace runs straight down through five internodes

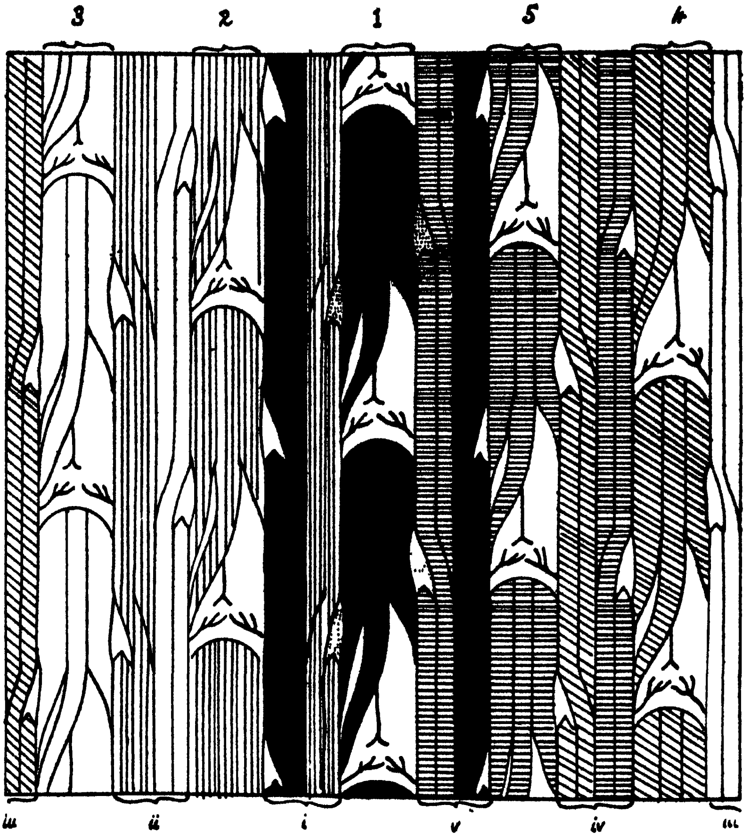

FIG. 3.—Nodal plan of *Quercus* to show the course of the leaf-traces in the stem. The whole stele is shown unfolded in one plane, two complete leaf patterns being included. Ridges (1–5) and furrows (i–v) numbered to correspond with fig. 1. The leaf-traces from the five leaves of a pattern are shaded differently. Vertical scale much reduced.

(one leaf pattern) then moves over towards the bud, thus opening the gap for the entrance of the corresponding lateral from the leaf immediately under its leaf of origin. The lateral traces then run through one more leaf pattern before fading out (see nodal plan, fig. 3).

The node of *Quercus* has been previously described by

Frank (4), with whose results these agree in the main. He describes, however, a branch from the median trace of the leaf vertically above the node of origin as contributing to the bud ring at the latter node. This is incorrect.

Langdon (7) also describes the anatomy of the seedling buds of *Quercus alba* and *Q. rubra*. Her results differ slightly from those obtained from the adult stem, as might be expected.

NODAL STRUCTURE OF PLATANUS.

General Structure of the Foliage Twig.

The twig of *Platanus* is dark green, flattened oval in shape, and generally somewhat twisted as growth proceeds. The leaves are petiolate with large stipules which clasp the stem and may persist after leaf-fall. The leaf-scar entirely surrounds the stem. The buds are small and pointed, totally enclosed in the leaf-base, and only visible after leaf-fall. The petioles are slightly twisted so as to bring the leaves into the same plane, but not so markedly as in *Tilia* (see below).

Phyllotaxis.

The phyllotaxis is two-ranked (distichous), but later growth-twists of the internode may slightly obscure this.

Vascular Structure. I. *Internodal.*

Platanus shows a markedly dissected stele, the stelar segments being separated by rays which are two to three cells wide. There is a large pith, and the segments project into it for varying distances. Sclerenchyma caps to the segments are early differentiated. The stele of *Platanus* is entirely composed of common segments.

II. *Nodal.*

At each node seven leaf-trace contributions enter the stele and seven gaps correspondingly appear (multilacunar type of Sinnott (10)). These may be designated median, M, laterals L1, L2, L3, and laterals L′1, L′2, L′3 (fig. 4). Their subsequent history is as follows.

Median.—The median contribution consists, at the stage when it is approaching the gap, of four distinct bundles (figs. 4 and 5). These enter the ring and then run vertically

downwards through one internode (sometimes splitting and reuniting *en route*). Taking the leaf of origin as leaf 1, at the internode corresponding to leaf 2 the medians move in pairs away from the mid-line and fuse for a time with L3 and L′3 from leaf 2. This results in the opening of the median gap for leaf 3. At the entry of the medians from leaf 3 the composite segment L3–MM splits temporarily, and then, moving still farther away from the mid-line, fuses with and

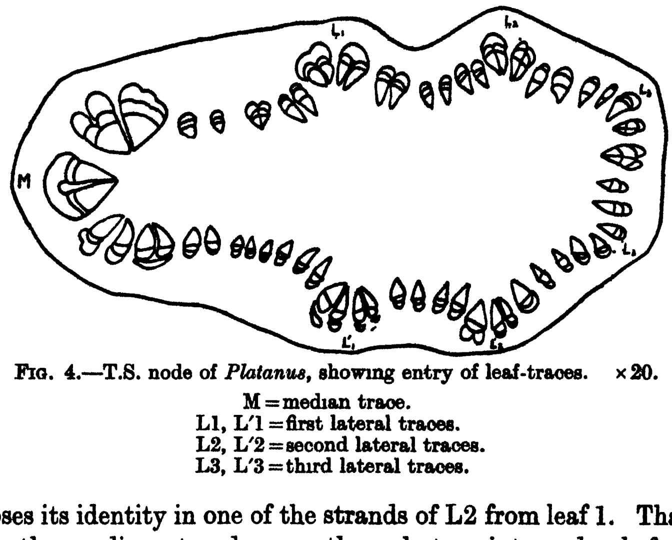

FIG. 4.—T.S. node of *Platanus*, showing entry of leaf-traces. ×20.
M = median trace.
L1, L′1 = first lateral traces.
L2, L′2 = second lateral traces.
L3, L′3 = third lateral traces.

loses its identity in one of the strands of L2 from leaf 1. That is, the median strands pass through two internodes before losing their identity (fig. 5).

Lateral 1.—L1 is composed of two bundles. They pass unaltered through one internode, move apart during the second internode, and finally taper off on the corresponding bundles from leaf 3 (the leaf immediately below the leaf of origin), having temporarily fused with their adjacent laterals L2 and L1 from leaf 2 (fig. 5).

Lateral 2.—L2 is also composed of two bundles. The left bundle of the pair swings out in the second internode to fuse temporarily with the right bundle from L1 of the second leaf, while the right bundle of L2 receives contributions at different levels from the composite trunk L3–MM. After running together with these through the second internode, L2 swings back and fades off on the corresponding L2 of the second leaf, on which the remains of L3 also fades out at a lower level (fig. 9).

Lateral 3.—L3 consists of a single bundle. It fuses with MM during the first internode, runs conjointly with L2 through the second internode, separates from L2 at the third node, and finally fades out on L2 from the third leaf (fig. 5).

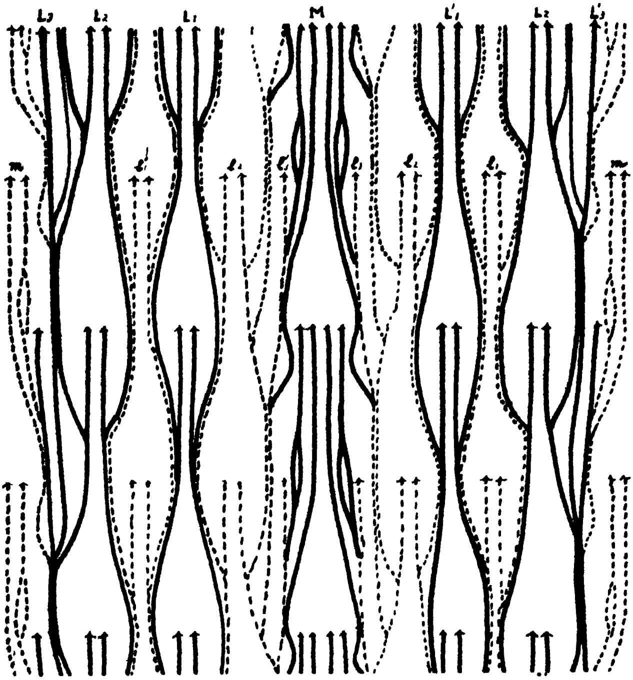

FIG. 5.—Nodal plan of *Platanus*, stele shown unfolded in one plane. Two leaf patterns shown. Traces from successive leaves in solid and broken lines alternately. Lettering as in previous figure (M, L, etc. = traces from leaf 1; *m*, *l*, etc. = traces from leaf 2).

It will be seen that the median traces have the shortest course. They separate and move away from the mid-line, each group, as it were, straddling the gap where the next medians enter immediately below.

The laterals L1 and L2 also move apart to leave the gap for their successors, but swing in to fuse with them after three internodes.

The third lateral slants steadily away from the mid-line, and after three internodes fades out on its adjacent L2, having combined with the median traces just previously.

The bud supply connects with the combined trunk L3–MM.

It will be obvious that the addition of seven leaf-traces, comprising fourteen bundles, at each node will result in a great expansion of the stele at the node, as mentioned above under *Quercus*. The effect of the node is very long-lasting: in fact the one-sided protrusion of pith and stele can still be seen less than 1 mm. above the insertion of the bud; the stele forms in fact an eight-sided figure with one larger curved side, the side towards the insertion of the bud. The pith shape is similar.

NODAL STRUCTURE OF ACER.

General Structure of the Foliage Twig.

The young twigs of *Acer* are smooth surfaced, grey in colour, and rounded hexagonal in shape. The leaves are petiolate and attached to the stem by large crescentic bases.

Phyllotaxis.

The leaf arrangement is opposite and decussate.

Vascular Structure. I. *Internodal.*

The young twig of *Acer* shows a definitely dissected stele, with twenty-four wedge-shaped bundles, widely spaced, and a large pith. The general outline of the stele in section is hexagonal, and it has two axes of symmetry, the longer lying between the angles of the stele corresponding to the nearest node, the shorter at right angles to it (figs. 6 and 7). The alternation at right angles of the successive pairs of leaves leads to a reversal of the position of the longer and shorter axes in each successive internode.

II. *Nodal.*

As there are two opposite buds and leaves at each node, which behave alike, one-half of the stem only will be described.

There are three leaf-trace contributions and three corresponding gaps (trilacunar node) in each half of the stem. Of the three traces the two laterals appear considerably earlier than the median—in fact they are to be seen running horizontally in the cortex even before the bud contribution has amalgamated with the stelar ring (fig. 6).

The median trace consists of three bundles—one large central

bundle flanked by two smaller ones. These three bundles come into the stem together, and together run down vertically through one internode. At the next node (node 3, immediately below the leaf of origin) the large central bundle splits and moves apart, and the two smaller strands meet and taper off on its flanks about half-way down the second internode. At the third node (that is, the node immediately under the leaf of origin) the two halves of the median strand separate

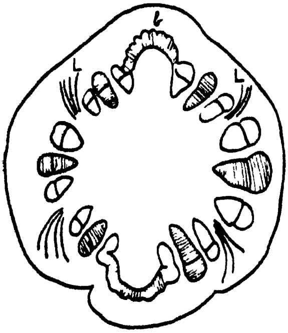

FIG. 6.

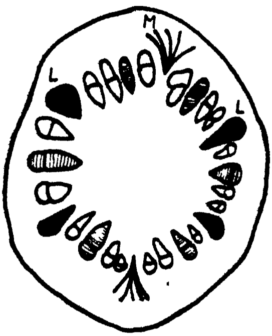

FIG. 7.

FIG. 6.—T.S. node of *Acer*, showing entry of bud-ring (*b*) and lateral leaf-traces (L). ×20.

FIG. 7.—T.S. node of *Acer*, later stage, showing entry of median leaf traces (M). The lateral traces are well within the main stelar ring (L). ×20.

still more to form the bud and leaf gaps for that node, and then curve in again in the course of the third internode, to fade out on the smaller median strands from the third node. It will be seen that the mid-median strand in each case splits and straddles its immediate successors—the whole median trace of the node immediately below it (see nodal plan, fig. 8).

The lateral traces enter the stelar ring before the median: they are composed of single bundles. They run straight downwards through one internode. In the second internode they move over towards the bud, then run vertically through a third internode before tapering off on the corresponding laterals from leaf 2. It will be seen that the mid-median and lateral traces keep their identity for almost the same distance; the laterals for slightly longer than the median (figs. 6, 7, 8).

The bud contribution is received on the inner aspects of

the halved mid-median traces from the node immediately above the bud (fig. 6).

The duplication of the triple leaf-trace contribution at each node leads to the hexagonal shape of pith and stele referred

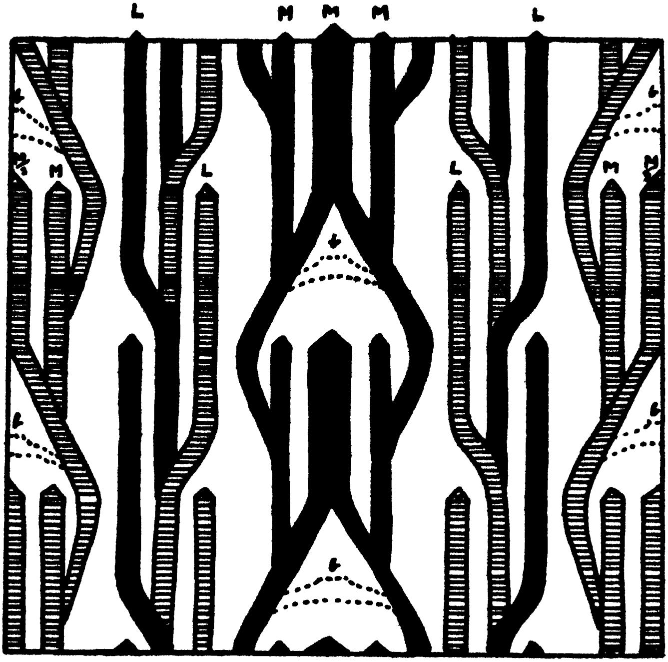

FIG. 8.—Nodal plan of *Acer*, showing stele unfolded in one plane. Vertical scale much reduced. The traces from leaves in the same vertical rank are shaded alike. M = median traces; L = lateral traces; *b* = bud-ring.

to above. The pith shape and the position of the primary segments can be seen in older branches owing to the persistence of the primary rays, even when secondary cambial activity has given the wood-mass a circular outline externally (compare with *Platanus*, *Tilia*, *Quercus*).

NODAL STRUCTURE OF TILIA.

GENERAL STRUCTURE OF THE FOLIAGE TWIG.

The general appearance of the spray of *Tilia* is flat, because the leaves are arranged alternately on either side of the twig, and their petioles are twisted so that the blades lie in one

plane. The stem is rounded in outline, slightly flattened from side to side, and is not straight but zigzag throughout its length. The foliage leaf is slightly asymmetrical, one lobe being larger than the other; in the young spray the larger lobes are directed towards the under surface of the twig, but in the mature spray the larger lobes are turned towards the stem, alternately right and left in relation to the whole spray.

Phyllotaxis.

The leaf arrangement is two-ranked, the leaves being attached alternately on the flattened sides of the twig. The leaf-scars are small and crescentic. A plane passing through the centres of the leaf-bases divides the twig symmetrically into an upper and lower half, and both the external and internal structures can be related to this plane of symmetry. The bud is a flattened oval structure, with one large outer bud-scale partially enclosing the rest. The buds are obliquely displaced (in regard to the leaf-scars) towards the upper half of the twig, and in consequence of this displacement the large outer bud-scale appears alternately to lie right or left of the twig.

Vascular Structure. I. *Internodal.*

The stele of *Tilia* is described as continuous ; that is, the stelar ring consists of a large number of close-set files of xylem separated by narrow strips of parenchyma. Even here, however, it is possible to distinguish in the very young stem that certain segments of the stele are delimited by wider strips of parenchyma. A study of the node reveals that these are, in fact, the last remnants of the leaf and bud gaps ; I propose to call them *gap-residues*. They persist for a varying length of time and finally merge into narrow rays.

A study of the development of the stele from the procambial stage is in progress. The results are as yet incomplete, but it may be said here that some at least of the protoxylem in *Tilia* is primary (that is, developed from procambium). The relations of the rays, gap-residues and intra-segmental files of parenchyma are being analysed.

The outer margin of the wood is approximately circular in outline, but the pith forms an irregularly seven-sided figure, with a protrusion towards the place of insertion of the nearest

bud. The stelar ring is therefore narrowest at this region. The protoxylem forms a series of fine points which do not protrude deeply into the pith.

II. *Nodal.*

Approaching the node the stele enlarges and then breaks to form the bud gap, the direction of the protrusion of the stele being directed towards the upper side of the twig, at an angle to the mid-leaf plane of symmetry referred to above. The bud stele approaches the gap, opens on the adaxial side, and approaches the main stele at the edges of the gap. The whole stele contracts a little, but not quite to the internodal size, and then the leaf gaps appear, the bud stele breaking on its abaxial side to give the median leaf gap (fig. 9).

The leaf-trace consists of a median and two lateral contributions (trilacunar type): as their times of entry and courses in the stem are somewhat different, they will be described separately as the median and the upper and lower lateral traces respectively, corresponding to the side of the twig to which they pass.

The slightly oblique setting of the leaf-base in relation to the bud leads to an inequality in the track of the leaf-traces (fig. 9). The median trace comes in and moves counter-clockwise, more or less horizontally, until it is opposite the protrusion of the bud stele at its junction with the main stele, where its gap appears; it then slants in and takes its place in the median gap, which is the last of the three leaf gaps to appear.

In the case of the lateral traces, the gap for the upper lateral appears first, then the lower lateral gap. The upper lateral trace moves counter-clockwise in a more or less horizontal direction round the stem; its track is longer than that of the lower lateral because it has to circle round the bud-stele protrusion. The lower lateral trace moves round clockwise till it is opposite its gap. The two lateral gaps appear directly opposite each other, and a line joining them at their first inception crosses the mid-leaf line at right angles. By comparison of successive serial sections it is seen that the upper lateral gap opens *away* from the mid-leaf line while the lower lateral gap opens *towards* it (figs. 9, 10).

The stele is now at its most expanded stage. The leaf-

traces are still more or less horizontal but are approaching their gaps. The traces enter the gaps in the order of their appearance, and the two lateral traces are always well within the ring before the median. The median trace at this stage is seen to be triple, but the segments unite before it joins the

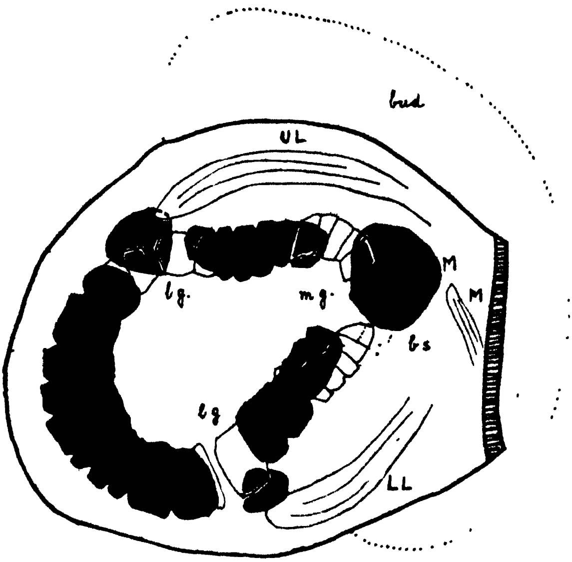

FIG. 9.—T.S. node of *Tilia*, showing stages in the entry of bud- and leaf-traces. ×25.

(i) The bud is shown displaced towards the upper side of the twig; the bud-ring (*b.s.*) is drawn with a dotted line.
(ii) First appearance of the leaf gaps: *m.g.* = median gap; *l.g.* = lateral gap. All three traces (drawn with a fine line) are seen running more or less horizontally in the stem, the median and upper later traces moving counter-clockwise towards their gaps, the lower later moving clockwise towards its gap.
(iii) The leaf-traces are just entering the main stele (solid black), the gaps being open to their widest extent.

stele of the branch. All three traces penetrate the ring deeply, being seen for a short distance distinctly protruding into the pith.

In following the course of the leaf-traces after they have joined the stele series of transverse sections were cut through six or seven successive nodes. In the case of a continuous stele the close setting of the segments makes it difficult to follow out the vertical courses of the traces by this method alone, so that recourse was had to injection methods by which

coloured solutions were forced into the petiole. It was found that the dye had been forced back in the leaf-trace segments for about six nodes below the insertion of the experimental leaf. By a combination of these two methods the course of the traces was determined as follows.

The median segment pursues a straight vertical course through two internodes, and then fades out at the bud gap

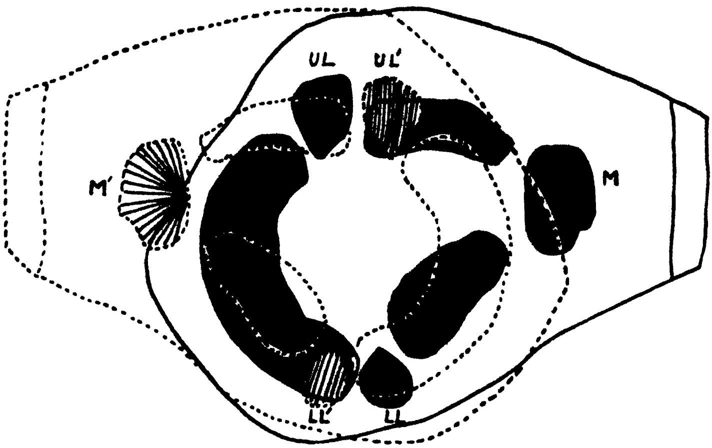

FIG. 10.—Tracings of two successive nodes of *Tilia*, superposed to show the symmetry of the system. ×25.

M, UL, LL = median, upper and lower laterals of node 1.
M′, UL′, LL′ = median, upper and lower laterals of node 2.

Note that a line joining the median traces divides the stem into an upper and lower half, while a line joining the beginnings of the lateral gaps is at right angles to this. The upper lateral gap opens away from the bud, the lower lateral gap opens towards the bud.

of the bud immediately below the leaf of origin, the trace tapering off to the left of the mid-line of the bud. (Taking the leaf of origin as leaf 1, the median trace fades out at leaf 3.) (See nodal plan, fig. 11.)

The lateral leaf-traces pursue a longer course. The laterals from successive leaves come in to right and left of the transverse diameter of the section alternately. The laterals extend vertically through six internodes, but not in a straight line, because they move over at alternate nodes to accommodate the corresponding laterals from the successive leaves immediately below their leaves of origin (fig. 11). Both upper and lower lateral traces move counter-clockwise round the stem in their sinuous course; it will be seen that they each

approach a median segment and finally taper out at the bud gap of the third leaf under their leaf of origin. (If the leaf of origin is called leaf 1, the laterals fade out at leaf 7.)

It will also be seen that the major part of the stele is composed of lateral leaf-trace segments.

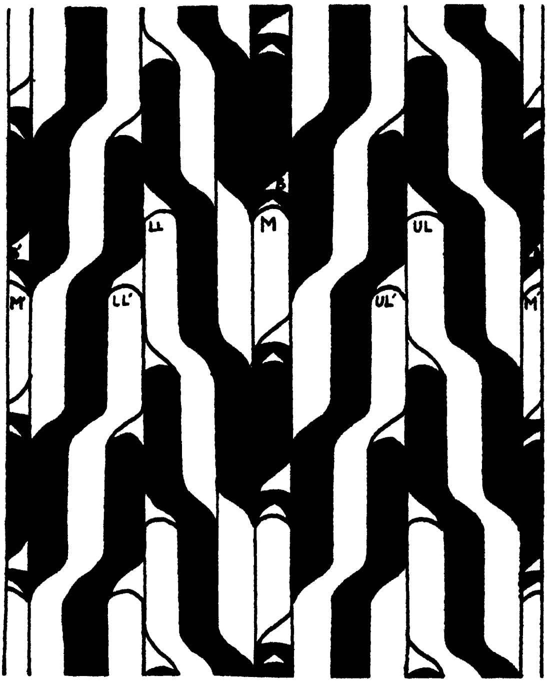

FIG. 11.—Nodal plan of *Tilia*, showing the stele unfolded in one plane. Vertical scale much reduced. Two leaves constitute a pattern. Alternate leaf patterns black and white.

M, UL, LL = median, upper and lower laterals of leaf 1.
M′, UL′, LL′ = median, upper and lower laterals of leaf 2.
B = bud supply.

DISCUSSION.

The three types described which show a dissected stele in the young stem (*Quercus*, *Platanus* and *Acer*) all maintain this character in the older stem: persistent wide rays continue to cleave the woody mass, and as long as the pith is intact the original structure of the young stem can be clearly discerned by examination of the pith border. In all these cases numerous secondary rays of minor duration and importance appear (see Bailey, I. W. (1)).

A study of the procambial stage in all four types confirms Kostychev's statement (6) that a continuous procambium ring is the most common case in Dicotyledons—the dissected stele being arrived at by "parenchymatisation" of segments alternating with the vascular segments. A detailed study of this is in progress, with a view to a comparison of the development of the continuous and dissected type of stele in the early stages of growth. Kostychev (6) states that "the leaf-traces in a young wood-bast ring (continuous stele) must be sharply distinguished from the true vascular bundles. They are distinct morphological elements, resulting from a correlation between leaf and stem development." This would imply that in a stem like *Tilia* the "leaf-traces" are to be distinguished from the "true vascular bundles." It has been shown that the stele of *Tilia* is entirely composed of common segments, so that Kostychev's statement does not apply to this case. This point seems to need further analysis.

A feature which has emerged in these preliminary studies is the dominance in the young axis of the structural pattern imposed by the phyllotaxis. This is not new, but can bear to be reaffirmed. The striking studies by Louis (8) of the development of procambium from promeristem in the apex of *Syringa*, etc., re-emphasise this. He shows that the procambial segments destined to become vascular segments differentiate simultaneously in the leaf primordium and in the "soubassement foliaire," and that the full vascular pattern is not established until a certain number of nodes (depending upon the phyllotaxis) have developed. The statement of Langdon (7) that the procambial strands in *Quercus rubra* and *Q. alba* initiates in the leaf primordia and develop both basipetally and acropetally needs re-examination in the light of this newer work.

The phylogeny of the angiosperm stele, about which much has been written (see, for example, Jeffrey (5), Eames (3), Sinnott and Bailey (11, 12)) cannot profitably be considered until much more is known of its ontogeny in the adult shoot.

Particularly is this the case in an attempt at a comparison between the continuous and dissected type of stele (see Eames (3), Kostychev (6), Louis (8)).

It is obvious that much work is still needed on the primary vascular system of the angiosperms.

Summary.

1. In the four types studied the whole stele was composed of common segments.

2. *Quercus*, *Acer* and *Tilia* correspond to Sinnott's trilacunar type, *Platanus* to his multilacunar type.

3. In all four types the median leaf-trace contribution and the bud contribution persisted through one leaf pattern only, making way for the corresponding contributions from the leaf immediately below the leaf of origin. The number of internodes involved in one leaf pattern varies with the phyllotaxis, being two in *Platanus*, *Acer* and *Tilia*, and five in *Quercus*.

4. The median leaf-trace at the time of its amalgamation with the main stele consists in *Tilia* of one segment, in *Acer* of three segments, in *Platanus* of four and in *Quercus* of five segments.

5. The lateral leaf-trace contributions in all cases persist for a considerably longer time than the median, enduring for several leaf patterns before fading out.

6. Just before the entry of the leaf traces the main stele shows a considerable transverse expansion and the gaps are evident as wide bands of parenchyma. Even after the leaf-traces have entered the stelar ring and it has contracted to its internodal size, the new segments are delimited by gap-residues, which persist for at least one internode before merging into rays.

7. In *Quercus* and *Acer* the persistent wide rays in the older stem are also related to the gap-residues.

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Studies on the Genera Cytisus and Genista.

By R. A. Taylor, B.Sc., Ph.D.

(Read 18th March 1937.)

Considerable variation is shown among the species of *Cytisus* and *Genista* in the extent of xerophilous adaptation. Many species have the "switch" habit, stems may or may not be "ridged" or "winged," and leaves may be tri- or unifoliolate, petiolate or sessile. Stipules are present in most but absent in some species, and all these characters have been used in classification.

In the present paper the serial section method has been applied to the study of the vascular system of root and shoot. As many species as were available were examined, particular attention being paid to nodal anatomy. Root and hypocotyl will receive a brief mention and the different stem types will be dealt with in greater detail. Finally, an attempt will be made to classify the species on an anatomical basis.

Root.

In all cases examined a perfectly normal diarch stele was found.

Hypocotyl.

Two types of transition were found, namely, those diagrammatised by Eames and MacDaniels (l. p. 243) as types *b* and *c*. An example of the first type is found in *Cytisus albus* and of the second in *C. supinus*. Below the cotyledonary node the bases of the cotyledons together encircle the stem. At the node the edges separate at a lower level on that side of the stem which is to bear the first foliage leaf, as indicated by the position of the leaf-trace already apparent in the stele of the stem.

The Stem.

The stem of the young seedling is almost cylindrical even in types which, in the adult state, are ridged. The stele in all cases is of the continuous type, although in any transverse

section of an internode five wider portions with protoxylem groups projecting into the pith can be seen.

The outline of the transverse section of an internode of an adult plant varies with the species, but all of those studied, except *Genista horrida* and *G. sagittalis*, fall more or less into one or other of the types shown diagrammatically in fig. 1.

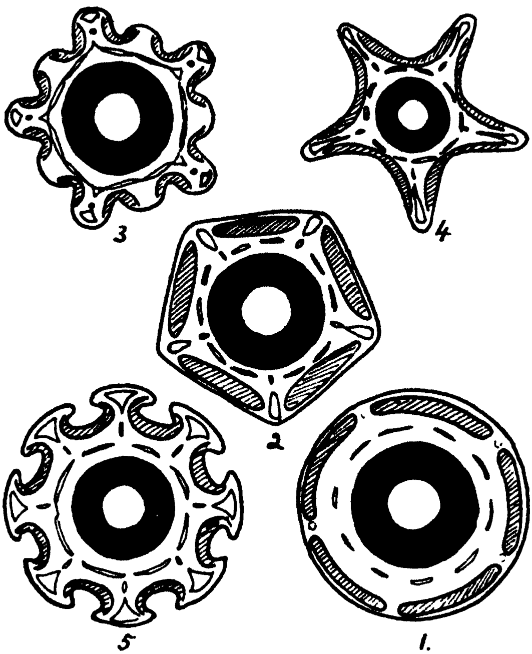

FIG. 1.—Diagrammatic representation of stem types as seen in transverse section. Xylem in solid black, assimilating tissue shaded, and sclerenchyma outlined.

In Type 1 the stem is almost cylindrical, and this in all probability is the most primitive. Thus it is seen in most of the more woody species, such as *Cytisus purpureus*, and in the youngest stages of all species specially studied. The groups of fibres shown in the cortex may or may not be present, and probably were absent from the ancestral type.

The five-angled stem is shown in Type 2 and it would appear to be a development from Type 1. The five cortical groups of fibres are now larger and occupy positions in definite angles of the stem.

In Type 3 there are five prominent ridges, each containing

the usual group of fibres, and in addition a small vascular bundle, normally orientated.

In Type 4 the five corners seen in Type 2 have been extended into "wings." It is interesting to note that in none of the "winged" species were "cortical bundles" present.

Type 5 shows a specialised stem found in *C. Ardoini* and its near relatives.

In Table I an attempt has been made to arrange a number of species from both genera into groups corresponding to the five types just mentioned. Many occupy positions midway between some of these types, and this is indicated in the table.

The material used was, it is thought, typical of each of the stems studied, but, it should be pointed out, a ridged or winged condition is really only pronounced in the later branches when these have reached the adult stage.

Further, in no case of stem conforming to Type 1 were "cortical bundles" found.

The Leaf-trace System.

Both genera contain species with a triple leaf-trace system and species with a single trace. The two types have been called by Sinnott (2) the trilacunar and the unilacunar respectively. All these strands leave gaps in the main stem stele at their point of departure, although, in the cases of some of the smaller bundles, the gaps may be very small and liable to be missed in somewhat thick sections.

Where lateral leaf-trace bundles are present they always sever connection with the stem stele at a lower level than does the larger median bundle. The distance below the node at which they appear in the cortex may be relatively short or it may be considerable, extending in some cases to rather more than two internodes. Such small bundles coursing up the cortex are normally orientated, and in ridged stems occupy a central position in the ridges immediately under a small group of fibres.

Five species which illustrate the variation in nodal structure will be described individually. The first four are arranged in order of increasing distance travelled in the cortex by the lateral leaf-traces.

TABLE I

Type.	1.	1–2.	2.	2–3.	3.	3–4.	4.	5.	2–5.	3–5 (?)
With "cortical bundles"			*C. Linkii* *G. patula* (7-angled) *G. depressa*		*C. Hillebrandtii* *C. stenopetalus* *C. Fontanesii* *C. horniflorus* *C. Kewensis* *C. Everestianus* *C. canariensis* *C. fragrans* *G. florida* *G. pilosa stricta* (4-angled)					
Without "cortical bundles"	*C. hirsutus* *C. podolicus* *C. decumbens* *C. eriocarpus* *C. schipkaensis* *C. sempervirens* *C. Frivoldskyanus*	*G. tinctoria flore pleno* *C. ratisbonensis* *C. austriacus*	*C. nigricans* *C. biflorus* *C. Carlieri* *C. sessilifolius* (4-angled) *C. purpureus* (from *C. Adami*) *C. versicolor* *C. purpureus alba*	*C. filipes* *C. glabrescens* *G. (Retama) sphaerocarpa* (4-angled)		*C. Dallemorei*	*C. Reverchonei* *C.* "Lord Lambourne" *C.* "Lady Moore" *C.* "Daisy Hill" *splendens* *G.* "Mayfly"	*C. Ardoini* *C. Beanii* *C. pendulinus* *C. incarnatus* *C. praecox* *G. cinerea* *G. Villarsii*	*G. sylvestris-dalmatica* *G. hispanica* (?)	*G. aethnensis*

Cytisus stenopetalus.

This is a foliose species with ridged stem, and conforms to Type 3 above.

Tracings of representative sections from a series cut from below upwards through a node are given in fig. 2, stem outline and xylem only are shown. In section 6 two lateral leaf-traces are seen in the cortex, and, between them, the group of xylem elements which will form the median trace can be distinguished in the stele. In section 17 the main leaf-gap is open, and *C. stenopetalus* has therefore a trilacunar node. Following the series upwards we find in section 210 the lateral leaf-traces of the leaf next above already free from the main stele, and from this point to the node proper four "cortical bundles" are to be seen in any transverse section. As we approach the node the leaf base gradually becomes separated from the stem and it contains three vascular bundles. These soon fuse, the laterals pursuing an oblique course to unite with the median, sections 259 and 261. Section 261 also shows that two branch traces are cut off, one from each lateral; these will supply the stipules, which may be observed as separate structures in section 282.

It will be seen that a transverse section of the stem of this species may show two or four, but never more than four, lateral leaf-traces in the cortex, and that these course as "cortical bundles" for about one and a half internodes.

Cytisus canariensis.

This is a species of very similar habit to the preceding. It has a trilacunar node and belongs to Type 3 (see fig. 3). The main difference is in the distance travelled in the cortex by the lateral traces. Any transverse section shows at least four of these "cortical bundles," and all five are to be seen for the greater part of any internode.

It is interesting to note that lateral leaf-trace "d" is replaced in the cortex before "e," these two having passed out to leaf 1. The desirability for this is seen when it is considered that another lateral from position "d" will be required for leaf 3, while one from "e" is called for only at the subsequent node.

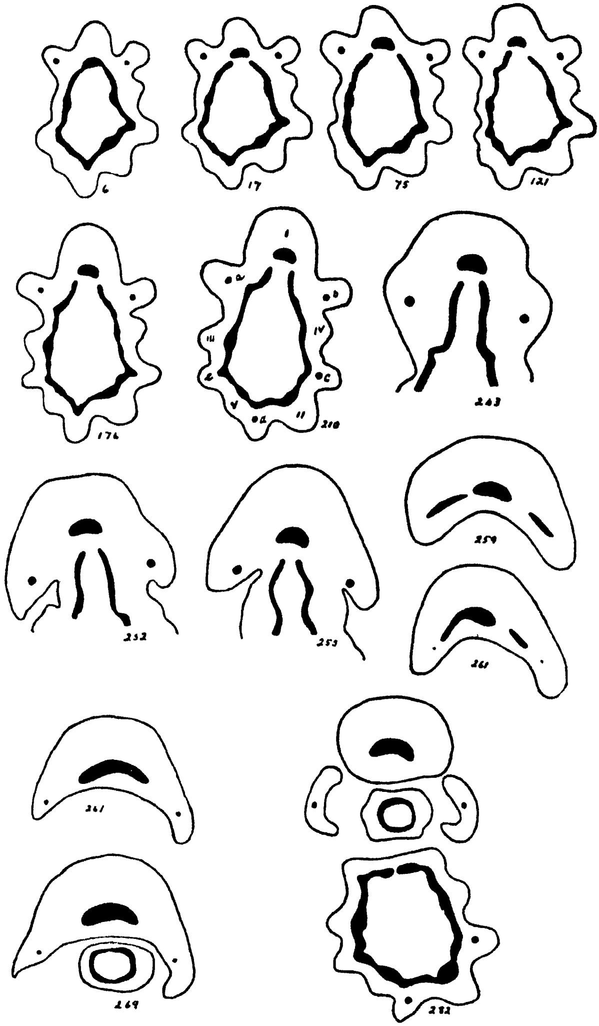

FIG. 2.—*Cytisus stenopetalus.* Tracings of representative members of a series of sections cut from below upwards through a node. Stem and leaf outline are shown and xylem in solid black. The numbers I to V indicate the points of departure and order of the leaves at the next five nodes. *a* to *e* give the positions of lateral leaf-traces while they are present as "cortical bundles." The arabic numerals give the numbers of the sections traced.

Genista tinctoria var. *elatior.*

The ridging here is not so pronounced and the leaf is unifoliolate and practically sessile. There are, however,

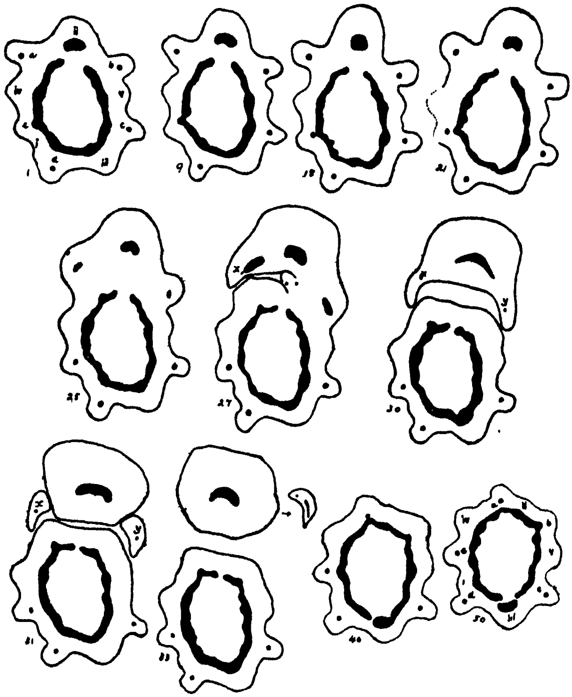

FIG. 3.—*Cytisus canariensis.* Tracings of representative sections from a series cut through a node. Numerals and letters as in fig. 2. *x* and *y* are stipular traces.

"cortical bundles" present, as seen in fig. 4. There are never fewer than four of these in any transverse section of the stem, and this condition only obtains at the base of an internode. Soon a fifth becomes separated from the main stele and a sixth is seen for a short distance below the node proper. These "cortical bundles" course as separate entities for a full two internodes.

Stipules are developed, but they are minute and are devoid of vascular supply.

G. tinctoria var. *apennina* is almost identical, except that occasionally only one minute stipule is developed.

Cytisus Linkii.

The condition seen in the two varieties of *G. tinctoria* holds here as regards "cortical bundles," replacement of those lost

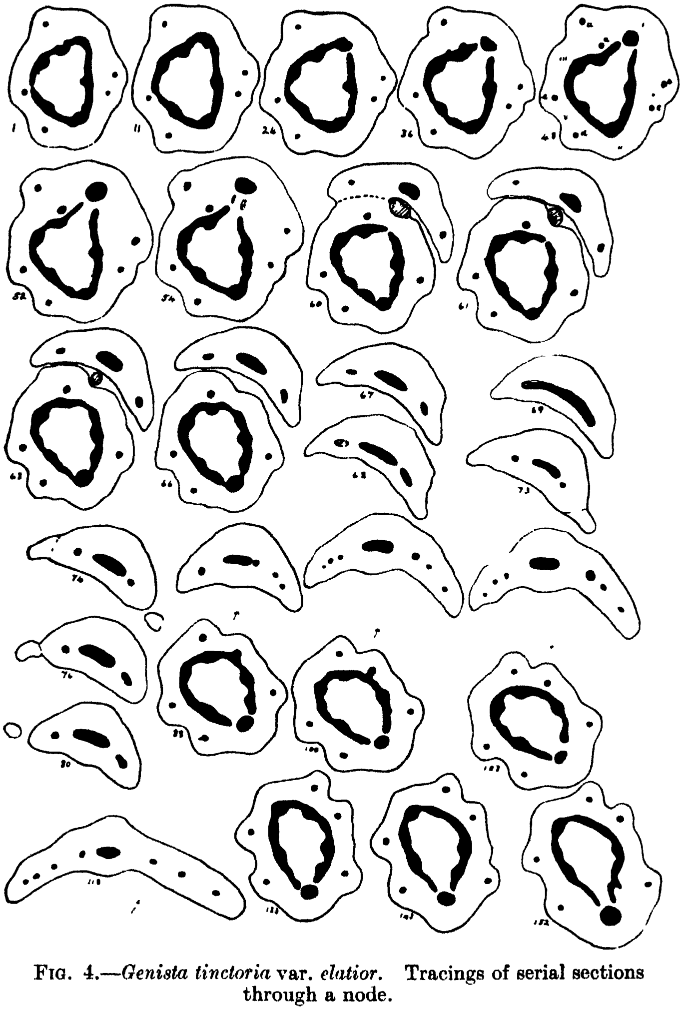

FIG. 4.—*Genista tinctoria* var. *elatior.* Tracings of serial sections through a node.

to a leaf is early. The main point of interest is the absence of stipules. The three strands of the leaf-trace fuse in the base of the petiole without any branching on the part of the laterals; no stipular traces are therefore provided.

Cytisus podolicus.

The stem of this species is not prominently ridged, also there are no "cortical" bundles, and the species therefore belongs to the unilacunar type. There are no stipules, and in all the species studied no example has been found of a unilacunar type with stipules.

Other examples of the type may be seen in *C. hirsutus* and *C. albus*. That there is no necessary relation between ridging and the trilacunar type is shown by the latter.

Summary.

1. There is little or no variety in root structure within the genera.

2. Two types of transition have been demonstrated.

3. Sinnott and Bailey (3) have shown that the development of stipules depends on the presence of the trilacunar type of node. This has been verified for the genera *Cytisus* and *Genista*.

4. Species can be roughly grouped by means of sectional outline and disposition of the vascular tissue, and it is thought that a complete survey of the genera on the lines here attempted would prove of value in connection with the relationships of the species.

References.

(1) Eames, A. J., and L. H. MacDaniels, 1925. An Introduction to Plant Anatomy, McGraw-Hill.

(2) Sinnott, E. W., 1914. Investigations on the Phylogeny of the Angiosperms. 1. The Anatomy of the Node as an Aid to the Classification of the Angiosperms. Amer. Jour. Bot., i, p. 303–322.

(3) Sinnott, E. W., and I. W. Bailey, 1914. Investigations on the Phylogeny of the Angiosperms. 3. Nodal Anatomy and the Morphology of Stipules. Amer. Jour. Bot., i, p. 441–453.

Stem Structure in the Maddenii Series of Rhododendrons. By Christine M. Cant, B.Sc. (With Pl. IX.)

(Read 20th May 1937.)

The majority of the species in the Maddenii Series of Rhododendrons is to be found in the region including Sikkim, Assam, Burma and Western China. In habit these species vary from shrubs to small trees, but a point of interest is their tendency to grow as epiphytes. The degree in which this tendency is exhibited varies, some species are always epiphytic, others are often so, while some which normally grow as shrubs may on occasion be epiphytes.

A rather unusual feature found in the Maddenii Series is a dilation which occurs at the base of the stem (Pl. IX, fig. 1). This swelling becomes visible while the plant is still young, and, as it persists, can be seen in full-grown specimens. On comparing several plants of varying ages no correlation could be found between the age and the size of the swelling.

Frequently, although not universally, there is a tendency for the dilation to give rise to several shoots at its apex instead of tapering off to give one main axis (Pl. IX, fig. 2). This habit will prove a useful possession if the necessity for regeneration occurs.

In order to study the actual anatomy of the swelling, sections were prepared from plants of several different species and of ages varying from one to nineteen years.

The year-old stems of the various species studied were uniform and normal. The cortex, bounded externally by the epidermis and a hypodermis, is composed of large and small cells, the latter being the richer in protoplasm. Bordering the stele is an irregular ring of cells, rich in protoplasm, which, in the light of what is observed in older sections, would appear to function as a cork cambium. An interesting feature is the presence of numerous medullary rays, in which there is considerable storage of food reserve in the form of starch.

Sections from the year-old plants taken in that region

which will later dilate do not show any unusual structural features. An additional point, however, is the presence of a layer of cork immediately internal to the cortex, isolating the latter and therefore causing its disintegration. Here

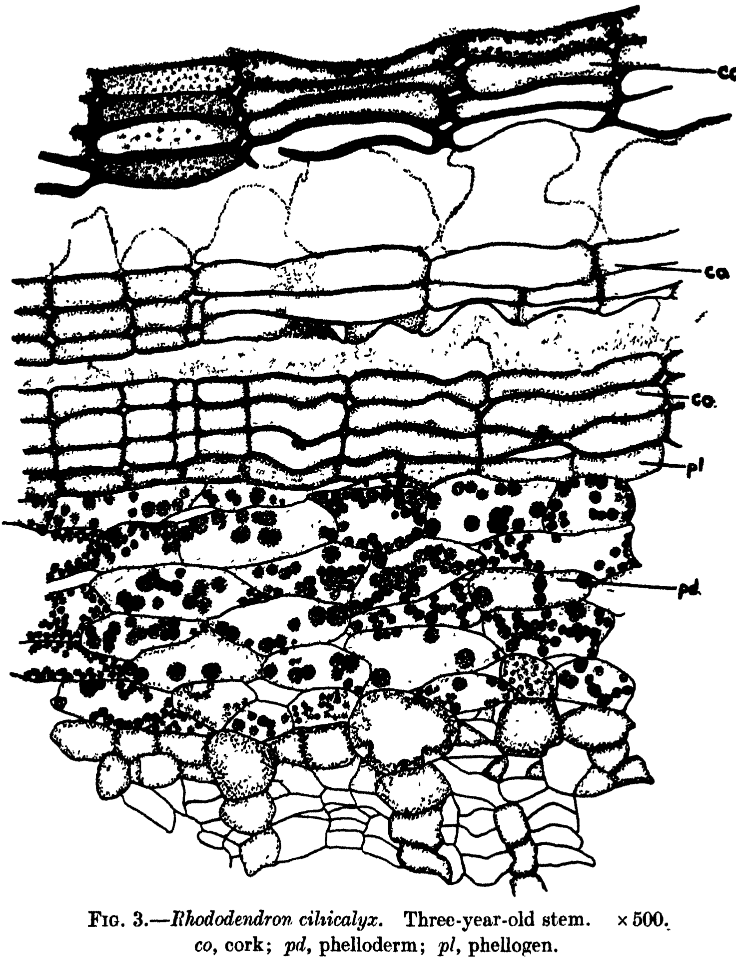

FIG. 3.—*Rhododendron ciliicalyx*. Three-year-old stem. ×500. *co*, cork; *pd*, phelloderm; *pl*, phellogen.

again the medullary rays are plentiful and contain starch. This substance is also present in the pericycle and in the tissue resulting from the inward divisions of the phellogen.

The features found in the young plants are found in an accentuated condition in the older specimens. Thus, in a section taken from the dilation on a three-year-old plant

of *Rhododendron ciliicalyx* (fig. 3) the cortex has entirely disappeared and the stem is bounded by cork. The cork tissue is in three layers, the division being accomplished by

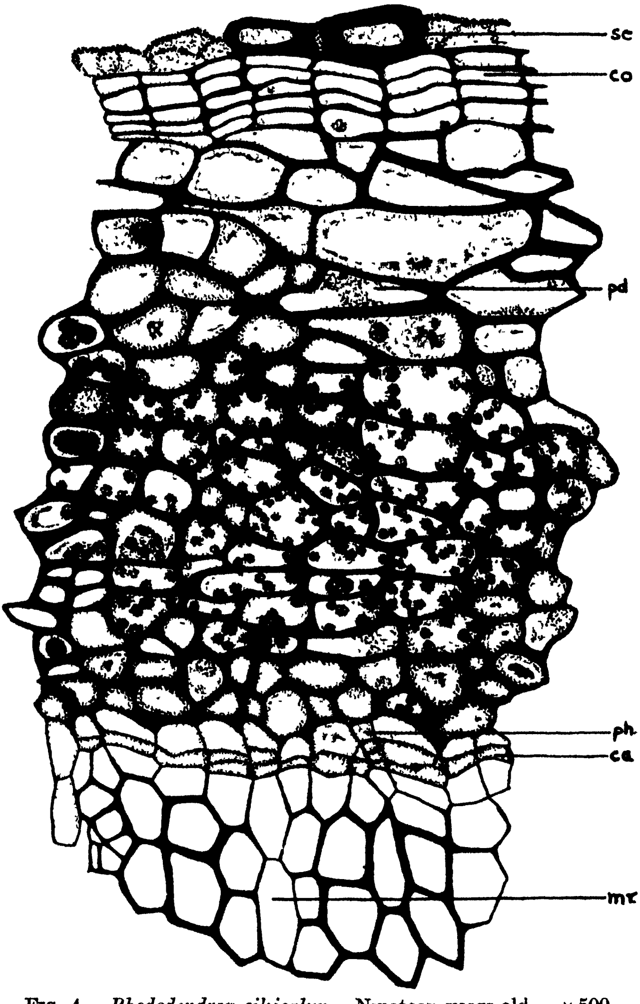

FIG. 4.—*Rhododendron ciliicalyx*. Nineteen years old. ×500. *ca*, cambium; *co*, cork; *mr*, medullary ray; *pd*, phelloderm; *ph*, phloem; *sc*, sclerenchymatous cell.

the presence of thin-walled cells. Internal to the phellogen are to be found the periderm and the pericycle with abundant food reserve.

The stem of a nineteen-year-old plant of *Rhododendron*

ciliicalyx (fig. 4) shows the same fundamental tissues to be present. The most interesting region here is a zone of thick-walled cells lying between the cork and wood cambiums. This zone must be composed of cells of the original pericycle and phloem, also cells produced by the inward divisions of the cork cambium, and finally secondary phloem produced by the wood cambium, but it is practically impossible to identify these separate types. It is this region which contains the starch reserve.

In reviewing the information obtained it will be seen that an examination of the dilation reveals no structural abnormality. The explanation of the swelling must then lie in the quantity of the tissues present, and not in their quality. When considering the tissues present in the swelling, the pith and the cortex can be ignored, the former because it decreases on descending the stem towards the root, and the latter because it disintegrates. The chief tissues now remaining are the wood, with its medullary rays, the phloem and the periderm, thus the swelling is probably due to extra development in these regions. As it is in these tissues that the major part of the food reserve occurs, the presence of the dilation allows for increased storage. As throughout this Series of Rhododendrons there seems to run a distinct epiphytic tendency, and also a decided preference on the part of most of the species for a rocky habitat, a reserve supply of food—in this case, starch—will be a useful acquisition. The manner of the storage will also be an advantage, as the large woody base provides additional strengthening tissue, which will be particularly useful in the case of the epiphytic species.

FIG. 1.—*Rhododendron Scottianum*

FIG. 2.—*Rhododendron burmanicum.*

CHRISTINE M. CANT.

Notes on the Tertiary Flora of Scotland.

By T. Johnson, D.Sc. (With Pls. X–XXII.)

(Read 20th May 1937.)

Introduction.

These notes are based on the examination of various collections of Tertiary fossil plants from the Isles of Mull, Canna, and Skye, preserved in the following Institutions: Royal Scottish Museum, Edinburgh; Grant Geological Institute, University of Edinburgh; Hunterian Museum, University of Glasgow; Glasgow City Museum, as well as from two new sites in the Isle of Skye. These collections were not included in the Revision (7) in 1924 of the Tertiary Flora of Mull by Seward and Holttum, which was based mainly on Tait's work a few years earlier at Ardtun and Carsaig in the Isle of Mull. Tait's material is under the care of the Geological Survey (Scottish Branch) in Edinburgh. The specimens from Ardtun on which Forbes reported (3) in 1851 are kept in the Geological Survey Museum in London. The collections made by J. S. Gardner (50) in 1885 under a Government Grant were deposited one half in the British Museum (N. H.) and the other half in Inverary. I was privileged to discover them there in 1930, but was disappointed to learn that the Duke of Argyll was unwilling to allow the collection to be examined or photographed but was prepared to consider an offer for its purchase. No account of the Mull fossil flora can be considered satisfactory which does not include this unnamed material. All my attempts to secure the collection or its determination have failed.

Specimens from Mull I have assigned to *Platanus*, *Quercus*, and *Cunninghamia* have been already described (19).

Age of Flora.

The existing flora of the British Isles bears little relation to the fossil one. It has therefore been necessary to take into consideration the flora of the S. and S.E. Europe, the

Canary Isles, Asia Minor, the Atlantic and Pacific sides of N. America as well as East Asia. For example, the fern *Onoclea*, abundant at Ardtun now grows in N. America and East Asia. Only one of the three native Conifers is reliably recorded in the fossil flora. It is sparsely found, in a form not closely related to *Pinus sylvestris*. Other fossil Gymnosperms are now confined to East Asia (*Ginkgo*, *Cryptomeria*, and *Cunninghamia*) or to the west coast of N. America (*Sequoia*), while the Araucarian and *Podocarpus* types are mostly or wholly to be found to-day south of the Equator. *Cupressus* is indigenous in Europe, in the Island of Crete only. It can be traced from Mull, etc., in a S.E. direction across Europe in the course of time. The two fossils I have referred to the Monocotyledons as *Pistia* and *Smilacites* connect with N. Africa or S. Europe. Similar results in change of distribution are obvious in a detailed consideration of the Dicotyledons described. As far as possible photographs are supplied so that the conclusions drawn may be checked by readers. Views based on inspection often of a single leaf are notoriously liable to error. In naming the fossils I have usually followed those writers who use the name of the living genus (e.g. *Platanus*) to indicate continuity of the living and fossil members of a genus, rather than the modified form (e.g. *Platanites*). The island sites of Mull, Canna, and Skye are comparable in origin to the continental island sites of Sotzka, Häring, etc., in the Eocene; Bilin, etc., of later date, regarded by Unger (60) as relicts of a vast continent sunk in a sea extending over Europe and Africa from 10°–55° N. with a temperature of 72°–81° F. This ocean would appear to be the Tethys Sea on whose N. shore grew the Indo-Malayan Flora of the London Clay Flora described by Mrs. Clement Reid and Miss Chandler. The general character of the Hebridean fossil flora favours the view of its circumpolar origin and subsequent radiation fan-wise southwards. The Canna site, made known by Heddle, and the two new sites in Skye brought to light by A. J. Inglis and G. V. Wilson respectively, will well repay further exploration as they help to fill the gap between the Arctic and Hebridean regions. The Ardtun site itself is, I understand, by no means exhausted. Many of the forms found fossil in Mull seem to have extended southwards before the destructive influence of the great lava

outflow followed by the Great Ice Age had brought about the annihilation of the local flora. When the Ardtun fossils were first observed Heer placed them in the Miocene. They are now generally accepted as belonging to the Eocene. According to Knowlton (20) many of the Mull forms are comparable to the Lower Eocene or Fort Union Flora of Montana, etc. The large orbicular leaf from Skye placed under *Populus* suggests comparison with leaves of the N. Siberian Province which Kryshtofovich (21) correlates with the Fort Union Flora. The almost complete absence of fruits, seeds, and animal remains makes a comparison of age with that of the floras of other localities, themselves often variously dated, more difficult.

I should like in conclusion to express my thanks for the facilities for my work provided by the Director and other members of the Staff of the Royal Scottish Museum, Edinburgh, as well as to Professor J. Walton (Hunterian Museum), Dr. R. G. Absalom (Glasgow City Museum), and to Dr. T. M. Finlay (Grant Geological Institute, University of Edinburgh) for photographs of specimens under their charge.

Dr. D. Russell has very kindly provided financial aid towards the cost of illustration of the paper.

THALLOPHYTA.

ALGAE.

Goniotrichum microscopicum sp. nov.

During the microscopic examination of material from Ardtun threads of a somewhat anomalous red alga *Goniotrichum* were revealed. The threads are unbranched and consist of a chain of rounded cells uniseriately arranged, enclosed in a thick sheath, half the diameter of the thread (20 μ) (text-fig. 1). *G. microscopicum*, this Ardtun fossil, suggests comparison with *G. elegans* (Chauv.) Le Jol (1). Its presence indicates connection of the Ardtun site with brackish or marine waters. *G. elegans* is one of three species described by Hauck. Its threads are sometimes unbranched and it is recorded from the British coast as *Bangia elegans* Chauv.

FUNGI.

It is of climatic interest to note that the epiphyllous fungus *Phragmothyrites* Edwards (2), found at Ardtun on a conifer leaf, also occurs at Washing Bay in N.E. Ireland on *Fagus* leaves at a depth of 900 feet. The group of which the genus is a member is rare in Europe (*e.g.* S. France) but is common in the humid wooded districts of S. Africa and S. America.

PTERIDOPHYTA.

FILICES.

Onoclea hebridica (Forbes).

In the short illustrated account of fossil leaves from Ardtun which Forbes gave in 1851 (3) one of the most interesting fossils is the fern named *Filicites* (?) *hebridicus* which Heer (4) noted was unlike any known European fern.

In 1870 Newberry (5) identified it as an *Onoclea*, scarcely differing from the common swamp fern *Onoclea·sensibilis* L. of Atlantic N. America and E. Asia. It was not until 1886 that Gardner (6) found an isolated scrap of 3 or 4 glomeruli of the fertile frond in which Edwards (7) later on obtained the radiate spores of the genus. There are many specimens of the sterile frond from Ardtun in the collections in the Hunterian Museum, Glasgow ("Koch" Collection), and in the Royal Scottish Museum, Edinburgh (Gardner's Collection). The "Currie" Collection from Ardtun includes a most illuminating specimen which deserves detailed consideration. It is an almost complete fertile frond or sporophyll of this fern, and is the most perfect specimen yet found (at Ardtun). It is 5×2 cm. in extent and shows, more or less completely, 9–10 alternating fertile pinnae (Pl. X, figs. 2, 3, and text-fig. 2).

The figure Warburg (8) gives of the sporophyll of *Onoclea sensibilis* L. would serve as an excellent restoration of the fossil. The fresh sporophyll is a pinnate leaf in which each pinna consists of 12–13 alternating pinnules reduced to rounded glomeruli. Each shortly stalked glomerulus is formed of several sori enclosed in the inrolled protective lamina of the pinnule on which the midrib and other veins are observable. This inrolling replaces functionally the relatively inconspicuous indusium.

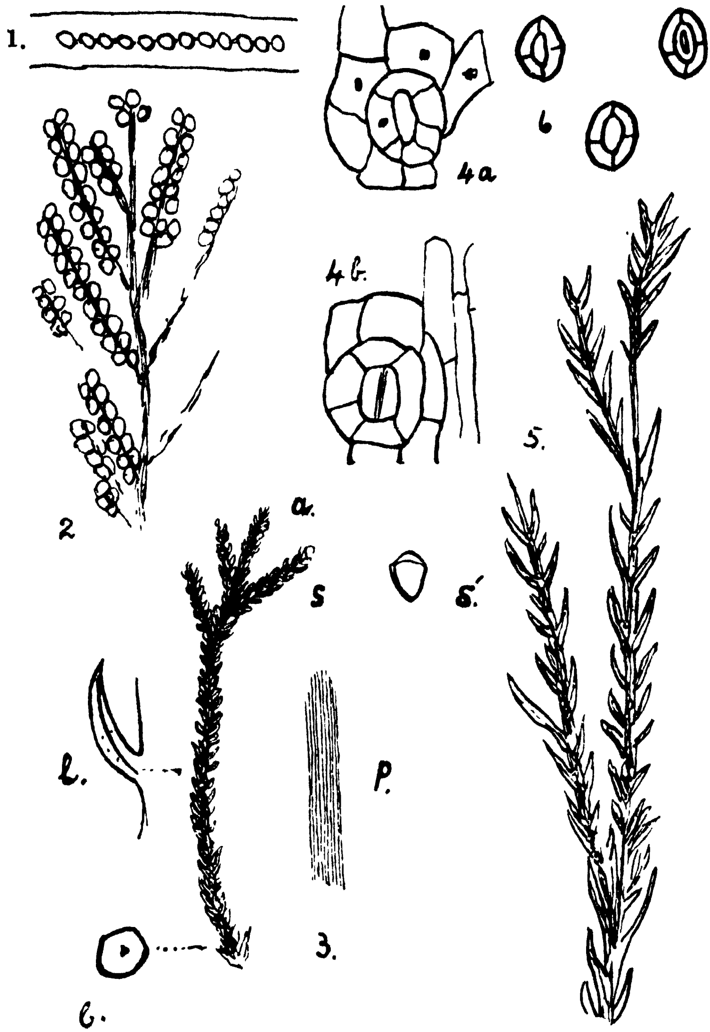

FIG. 1.—Thread of *Goniotrichum microscopicum*. (× 240.)

FIG. 2.—Sporophyll of *Onoclea hebridica* (Forbes). Ardtun. (× 1.)

FIG. 3.—*Araucarites Heddlei*. *a*, axis of twig, with 3 branches (× 1), *s*, fertile branch, with cone scale; *s'*, cone scale detached; *l*, leaf (× 3); *b*, branch-scar (× 3); *P*, leaf-fragment of a *Potamogeton*; from R.S. Museum counterpart.

FIG. 4.—*a*, Stomatal pit and ring of *Araucarites Heddlei*, from Canna; *b*, same of *A. excelsa*.

FIG. 5.—*Cryptomeria Gardneri*, Canna Isle, "Heddle" Collection.

FIG. 6.—Stomata of *Glyptostrobus europaeus*. Ardtun. (× 240.)

The radiate spores of *Onoclea* are readily obtained, as well as remains of receptacle and indusium, from the fossil.

Gardner attributed the failure of British botanists to recognise the affinities of *Filicites hebridicus* Forbes to the absence of any specimens of *Onoclea* in the British herbaria, though it is, it appears, one of the first ferns observed by a budding field naturalist in America.

A detailed comparison of the Ardtun sporophyll with the fossil from the Laramie formation in Colorado, which Lesquereux (9) named *Caulinites fecundus*, brings out the fundamental agreement of the two and fully justified Knowlton (10) in placing the Colorado fossil in *Onoclea*. The two fossils are very comparable in size, the pinnae make the same angle (20°) with the rachis as in the living species, and the pinnules appear as two rows of alternating glomeruli—1–1·5 mm. in diameter. These are the "capsules," "sori," or "sporangia" of various American writers and give the living form the name of *Pearl Fern*. Lesquereux (11) gives a figure of a sterile frond which, like the fertile frond, comes from Colorado and which he calls *Woodwardia latiloba*. I can see nothing in the illustration to distinguish it from *Onoclea* and am of opinion that Colorado, like Ardtun, yielded both sterile and fertile fronds of *Onoclea*. This view is strengthened by Lesquereux himself, who noted (12) the likeness of a fossil from Wyoming he described as *W. latiloba var. minor* to Heer's *Woodwardites arcticus*, which was later transferred by Heer himself (13) to *Onoclea*. The presence of *Onoclea* in the Cretaceous seems indicated by Hollick's *O. inquirenda* (14) from Magothy and Black Creek, Maryland, by *Osmunda petiolata* Hr. and *Osmunda Öbergiana* Hr. from the lower beds of Atanekerdluk in Greenland (15), all of which are explicable as fertile scraps of *Onoclea*. Heer (16) figured in 1883 an almost complete sterile frond from the Tertiary beds of Greenland as *Onoclea sensibilis arctica*, noting its similarity to the Ardtun fern. Diels (17) associates the isolated group of the *Onocleinae* with the *Woodsieae*, the earliest group of *Polypodiaceae* in his system. Bower (18) concludes that the *Onocleeae* are best regarded as a separate phyletic shoot from some Cyatheoid or tree-fern source, linking upwards with the Blechnoid ferns. The evidence on which this view is based is given with ample illustrations in

"Ferns." The explanation of the presence of this fern in the Eocene beds of Mull seems simple. *Onoclea* had a circumpolar origin in the Cretaceous, radiating southwards. Along one line it reached S. Carolina and Colorado, through the Magothy formation of Martha's Vineyard, Long Island, and Maryland, persisting to-day in Atlantic N. America from Canada to Florida. (Its fronds are described as sensitive to frost and as showing a seasonal leaf-fall.) Along another line it reached E. Asia (Amurland, Manchuria, and Japan), where it is still unrecorded in the fossil state. Along a central line it descended southwards over the "land-bridge" through Greenland to Scotland where it was destroyed by volcanic activity or during the subsequent Ice Age.

EQUISETALES.

Equisetum Campbelli Forbes.

The discovery by Forbes (22) of a horse-tail at Ardtun, which he named *Equisetum Campbelli*, helped, with *Onoclea*, to indicate the nature of the site as swampy ground bordering on lake or lagoon with, if *Goniotrichum* be accepted, a marine connection.

Seward and Holttum (23) gave the first adequately illustrated account of *E. Campbelli*, noting the surprising absence of signs of branching. In specimens in Gardner's collection in the Edinburgh Museum and elsewhere branching is obvious. The strobilus is still lacking. *E. Campbelli* occurs also in the islands of Canna and Skye. One piece sent by Mr. Inglis from a site he discovered near Portree in Skye shows an internode 5 cm. long and 1·2 cm. wide. A little tissue was obtained, including the characteristic stoma of *Equisetum*. One specimen showed a pronounced tumid node suggestive of secondary thickening such as occurs in *E. maximum*. It is necessary to go to the marshes of S. America to find a living form (*E. giganteum*) comparable in size to *E. Campbelli*.

GYMNOSPERMAE.

GINKGOALES.

Ginkgo adiantoides Ung.

The "living fossil"—the maiden-hair tree, *Ginkgo biloba* or *Salisburia adiantifolia*—is one of the most interesting plants. It is monotypic and now confined to E. Asia, cultivation

apparently saving it from extinction. The fossil records show that it had a wide distribution in the Arctic regions, N. America, and Europe, being found in Germany as late as the Upper Pliocene. Its fan-shaped type of foliage extends backwards to the Upper Devonian in various genera of ferns and possibly Pteridosperms. Heer was the first to isolate it from the ferns and to recognise it as a true Gymnosperm. The Ardtun site has yielded many of its leaves, well-illustrated by Gardner (24) as *Ginkgo adiantoides* Ung. They differ little from those of the living species. Its leaf is simple, stalked, fan-shaped, deciduous, more or less bilobed, without a midrib, with a double leaf-trace, often unobservable (or overlooked) in fossil impressions. The lamina is traversed by repeatedly dichotomised spreading veins between which are situated rows of cylindrical or rounded secretory sacs (Pl. X, figs. 4, 5; Pl. XVIII, fig. 3).

On splitting a slab from Ardtun showing several *Ginkgo* leaves a seed was revealed, split open, with every appearance of being a *Ginkgo* seed (Pl. X, fig. 5). It is an oval-ovate body, $1{\cdot}9 \times 1{\cdot}3$ cm. in size. Its cavity was filled by a jet-like substance through which layers of calcite (?) ran. Its wall is thick, seen only as a broken edge. It agrees in size and shape with the seed of *G. biloba* ($2 \times 1{\cdot}5$ cm.), but, owing probably to the position in the matrix, it does not show either the circumferential keel of the bicarinate sclerotesta of the more or less flattened (phatyspermic) "nut" of the living plant or its two basal vascular scars. Although juxtaposition of isolated structures is not proof of affinity, in such a case as this, in which we have a unique type of leaf and a seed in agreement with that of the living plant bearing that type of leaf, there is justification for the conclusion that at Ardtun we have the leaves and seed of *Ginkgo adiantoides* Ung.

The isolation of pollen grains of *Ginkgo* in the interbasaltic lignite of Mull by J. B. Simpson (25) adds an interesting feature to the Scottish record of the genus.

Pyritised seeds were recorded from the Isle of Sheppey as *Ginkgo* (?) *eocenica* by Gardner (26) who doubted their *Ginkgo* affinity on the ground that the climate of the Sheppey eocene would be too hot. Mrs. Reid and Miss Chandler have found (27) the specimens belong to an unidentified genus of the *Icacinaceae*, a tropical family.

It is of interest to add that Mr. G. V. Wilson in 1935 discovered a new site near Loch Gada in the Tertiary in the Isle of Skye, which has yielded already many examples of the leaves of *Ginkgo adiantoides*, thus adding a link to the chain of connection of European and Arctic localities of the fossil.

Mason (28) figures a leaf of *G. adiantoides* from the Oligocene of Oregon which is very similar in form to the leaf from the Cretaceous of Greenland called *Salisburea* (*Ginkgo*) *primordialis* by Heer (29) who shows seeds alongside. Seward (30), however, considers the leaf indeterminate. From Cretaceous and Tertiary beds in Sakhalin Is., Kryshtofovich (31) records undescribed species of *Ginkgo*. The circumpolar origin is thus evident.

CONIFERAE.

Araucarites Heddlei sp. nov.

Pl. XI, fig. 1 gives a photographic illustration of a branching coniferous twig [1] from the Isle of Canna, not unlike an annual shoot of several species of *Araucaria*. The fossil is 6 cm. long and 4 mm. wide. The axis itself is 2 mm. thick, closely covered by spirally arranged leaves, 1-veined, 3–5 mm. long, 1 mm. wide. Seen sideways the leaf appears acicular, more or less falcate, and pointed. In surface view it is linear-ovate, acute. A well-preserved leaf is seen to be more or less 4-sided. The leaf is only slightly decurrent, having a well-defined base, thus differing from a *Cryptomeria* leaf whose decurrent keeled base is traceable as a ridge on the stem surface for some distance. At the base of the fossil twig there are several rounded scars, with a central speck, comparable to those left by detached twigs of *Araucaria excelsa* and *A. Cunninghami* (text-fig. 3).

Stomata.

In an attempt to obtain tissue I was so fortunate as to isolate a leaf-tip, a curved shining brown black body comparable to the leaf-tips of *A. Göpperti* Sternb. isolated by

[1] In the examination of this and other fossils moistening with a solution of zinc sulphocarbolate in weak glycerine brings out features otherwise obscure and liable to be overlooked.

Miss Bandulska (32) from the Middle Eocene beds of Bournemouth. The tip on restoration by maceration and dissection revealed two bands of stomata, separated by many rows (12–15) of vertically elongated rectangular cells, with pitted straight walls. Each band reaches almost to the apex of the leaf, but is reduced for the most part to a single row of stomata with two horizontally elongated cells alternating between the stomata in the row (text-fig. 4). In one or two instances there are no intervening cells and the stomata are in direct contact. As is usual in a Conifer the stomata are sunk beneath the leaf surface. The depression or "outer respiratory" chamber, seen from above, is usually quadrilateral in outline. In half a dozen cases it was found still filled with a deposit of fine granular mineral matter. The depressed guard-cells with the pore, like the outer chamber mostly vertically oriented, were not easy to make out though the guard-cells stained well with methyl blue. The stoma is enclosed in a ring of 4 or 5 mostly elongated, narrow cells, occasionally in places double. The structure and distribution of the stomata agree well with the stomata of *A. Göpperti* as described by Miss Bandulska and with those of *A. excelsa*. The Canna leaves, 3–5 mm. long, are only half the length of those of the Bournemouth material. The rounded pits, papillae of Florin, noted in *A. Gurnardi* Florin, and not found in living *Araucaria*, occur also in *A. Heddlei* as I propose to name the Canna fossil.

Cone-scale ?

Close to the tip of one of the side-shoots of the fossil there is a scale-like impression, 5×7 mm. in size, not unlike the disc figured by Gardner (33) as *Doliostrobus Sternbergi* Gppt., and other scales suggestive of Araucarian affinity.

The fossil I have named *Araucarites Heddlei* is figured by Gardner (34) under *Cryptomeria Sternbergi* Gppt. as coming from Mull instead of, as it does, from Canna Island. Unaware of this error Seward and Holttum consider (35) that a scrap, from Mull, in the Tait Collection, appears identical with this fossil. They note the difference from *Cryptomeria* and likeness to *Araucaria excelsa*, etc., but in the absence of cones prefer to place the twigs under the non-committal name of *Pagiophyllum Sternbergi*. They consider the Mull (*i.e.* Mull

and Canna) specimens identical with *Araucarites Sternbergi* Gppt., recorded from the middle Eocene beds of Bournemouth and closely allied to *Araucarites Gurnardi* Florin (36) from the Oligocene of Bembridge.

Owing apparently to an overlooked discrepancy in Goeppert's Monograph (37), between the numbering of the figures given in the descriptive text on p. 237 and that given on p. 276, and used for the plate figures, an unintentional injustice is done to Goeppert when Seward (38) states that he "has compared *A. Goepperti* Sternb. to a male cone of *A. imbricata* incorrectly spoken of as *A. excelsa*." "Fig. 4" on p. 237 is fig. 2 on Pl. XLIV (p. 276) and is the male cone of *A. imbricata* (taken from Richard's "De Coniferis" and very similar to the figure in Veitch's Conifers) and numbered Pl. XLIV, fig. 3 (p. 276) ("fig. 5" of p. 237).

The male and female cones of *A. excelsa* R. Br. are given on Pl. XLV, figs. 1 and 2, by Goeppert.

Cryptomeria Gardneri sp. nov.

One of the fossils from the Isle of Canna bears a striking resemblance to a foliage shoot of *Cryptomeria japonica* (Pl. XI, fig. 2). The impression shows a small terminal tuft of branches arising at a very narrow angle (20°–25°). The stem is very thin, 1 mm. wide, and bears linear-aristate falcate leaves, 8–9 mm. long, making an angle of 20°–25°, usually, with the stem. The leaves are spirally arranged but appear in the impression as if distichously arranged. A helpful feature in the identification is observable in a lateral view of the leaf. Its single vein appears excentric in its passage from the base of the leaf into the stem, owing to the adaxial expansion of the leaf at its point of attachment to the stem, the surface of which shows the projecting ridges or keels of the decurrent leaves. Heer called attention to the diagnostic value of this apparently excentric vein. It serves to distinguish a *Cryptomeria* from (*e.g.*) *Sequoia* and other Conifers.

The stoma of *Cryptomeria japonica* shows small guard-cells (40–46 μ long), a little depressed beneath the leaf-surface and surrounded by 4–6 epidermal cells which form a much narrower border than in the case of *Sequoia gigantea* with its larger stoma (56 μ long).

The Canna material yielded a little tissue in which a stoma,

agreeing with that of *C. japonica*, was found. The likeness of this Canna fossil to the cone-bearing *Cryptomeria Sternbergi* Gardner is obvious. This specific name as employed by Gardner (39) is, however, out of place here. I propose to name the Canna material *Cryptomeria Gardneri* in honour of J. S. Gardner, who first described *Cryptomeria* from the Tertiary beds of Co. Antrim (Ballypalady and Glenarm). Gardner saw in the Irish material agreement (in part) with the fossil named *Araucarites Sternbergi* Gppt. from Häring, etc.; and called it *Cryptomeria Sternbergi* Gppt.

Goeppert's name (40) was given to foliage in compliment to Sternberg (41) who had assigned the name *A. Goepperti* [1] to a cone from the same locality and belonging possibly, said Goeppert, to the same "plant" that bore the foliage. It has been overlooked, leading to much confusion, that on p. 231 of his Monograph, Goeppert acted on this view and suppressed his name *A. Sternbergi*, treating it as a synonysm of *A. Goepperti*. Further confusion has been caused by an apparent error in transcribing in Gardner's account (42) of Scottish material. Following his account of the Irish *Cryptomeria* he adds "it, or something like it," occurs in the Islands of Mull and Canna. Fortunately the material figured by Gardner is still available. The "Mull" specimen comes from Canna and is, I suggest, Araucarian in affinity. His "Canna" fossil comes from Ardtun in Mull and is labelled in the "Koch" Collection *Glyptostrobus*. Neither specimen shows agreement with the specimen, not seen by Gardner, from Canna in the "Heddle" Collection I have named *Cryptomeria Gardneri* (text-fig. 5).

Cupressinoxylon sp. nov.

This collective name is given to a coniferous wood, usually Taxodiaceous in character, without resin-passages and other features of distinguishing diagnostic value. It has been applied by Seward and Holttum (45) to the fossil tree of Burgh, better known as MacCulloch's Tree. The photographic illustration shows the spring and autumn tracheides of an annual ring and at the same time the disintegration of the

[1] Florin has revived for this cone the non-committal name *Conites*, used by Goeppert for 8–10 different cones. Presl, he states, gave the first name (*A. Goepperti*).

material of a piece of wood of this tree (Pl. XV, fig. 1). I have received similar wood from Canna and Skye. *Podocarpus*, *Sequoia* and *Cupressus* have each been suggested as its possible modern representatives.

TAXODIACEAE.

Glyptostrobus europaeus (Brgt.).

The numerous records of the occurrence of *Glyptostrobus* and of *Taxodium*—the swamp Cypresses of S.E. China and of S.E. North America respectively—in the fossil state need reconsideration in the light of the evidence provided by the detailed account (46) of the distinguishing features of the living forms of the two genera by Henry and McIntyre. They give the first complete description of the only living species of *Glyptostrobus*—*G. pensilis* Koch (*G. heterophyllus* Brgt.), including particulars of three types of leaf and their ontogenous distribution. They show that branchlets may bear one type of leaf only. Such detached branchlets when found in the fossil state might well be assigned to different genera.

Miss Bandulska carried out a microscopic examination of material from the Middle Eocene beds of Bournemouth of a fossil conifer referred by Gardner to *T. europaeum*. The evidence she collected, based on a comparison of the stomata and other features, suggested to her that *T. europaeum* was a synthetic form diverging in one direction to give *Glyptostrobus* with the rosette type of pore, and *Taxodium* with the quadrangular type. Both of these types occur in the fossil form she examined. Henry considered the fossil is a *Glyptostrobus*, but that more Eocene material should be examined. He also expressed the view, verbally to me, that attention must be paid to the characters of the various types of leaves on trees in different stages of development and in their permanent and temporary branches. Henry, working on these lines, found the quadrangular type of stoma in the taxodioid type of leaf of *Glyptostrobus heterophyllus* and the rosette type in the cryptomeroid and cupressoid types of leaf.

The extensive deposits of lignite or brown coal of Central Europe are derived from *Sequoia* and *Taxodium*, according to conclusions based on the characters of the wood. How far *Glyptostrobus* enters into its composition is uncertain.

Henry expresses the opinion that it is extremely unlikely that the two genera, last-named, would be present in the same deposit. Saporta explains their rarity in northern regions by contrast with *Sequoia* as due to the comparative lateness of their migration southwards from the Arctic regions, following on that of *Sequoia.* Berry's account (49) of the migration of *Glyptostrobus* in N. America may provide an explanation. The genus is found there from the basal Eocene to the Pliocene, ascending in a north-west direction from the Mississippi region, Rocky Mountains region, and along the shores of the Arctic to Mackenzie River and Greenland, from which it could migrate southwards to Britain and Central Europe. Berry ascribes the scarcity of the Swamp Cypresses in the basal Eocene of S.E. North America (*e.g.* the Wilcox formation in Tennessee) to the torrid temperature of that period which drove the temperate types northwards into and beyond the Arctic Circle. Berry expressed the opinion, before Henry's investigation, that several different species are inextricably entangled under the designation *Glyptostrobus europaeus*; a critical examination of material from different localities being needed. Henry does this for the living forms and gives a list of fossil records, mainly from the works of Heer and Berry. He accepts Gardner's record for Ardtun, quoting Seward as confirming it though he simply lists it on Gardner's authority. Gardner writes of the presence at Ardtun "of coniferous branches like the living *Taxodium* (*Glyptostrobus*) *heterophyllum* and *Cephalotaxus*, though unfortunately every effort to remove and preserve these specimens has failed." He, however, gives a figure (50) of a branching foliage shoot which he vaguely states appears to belong to or to be similar to that described as *G. europaeus* by Heer.

The "Koch" (51) Collection in the Hunterian Museum contains two fossils from Ardtun, referable apparently to *Glyptostrobus*. One of these (Pl. XI, fig. 3) agrees with the figure Gardner gives (52) of a foliage shoot attributed to *Cryptomeria Sternbergi* "or something near it" and erroneously described as coming from the Isle of Canna, instead of, as it does, from Mull. I regard it as a detached branchlet, showing the adpressed *cryptomeroid* type of foliage of *G. europaeus* as illustrated in Henry's fig. 2 of Pl. IV, as also

in fresh material from Hong Kong, given to me by Henry. Stomata were obtained from Koch's specimen of the rosette type in agreement in general with those in Henry's fig. 11 of Pl. IV, and with Miss Bandulska's figure of *G. heterophyllum* on Pl. XXI, fig. 37. The epidermal or stomatal cavity or pit is oval and surrounded by a ring of four cells, not five or six as is more usual in the rosette type of stoma (text-fig. 6).

Further evidence of the occurrence of *Glyptostrobus* at Ardtun is indicated by the discovery of a pollen-grain by J. B. Simpson in the interbasaltic lignite of Mull. Comparison with the pollen-grain of *Glyptostrobus* is tentatively suggested by him.

The cones and seeds of the two genera *Taxodium* and *Glyptostrobus* are markedly different but are rarely found in the fossil state. It is worthy of note that the *Taxodium* cone, judging from Sargent's figure of the young cone (55), passes through a condition represented in the mature cones of *Glyptostrobus*. This would seem to indicate that *Glyptostrobus* is the earlier form to appear. *Glyptostrobus* possesses a pyriform cone, with imbricate cone-scales, having an upper crescentic crenate edge and a dorsally grooved surface.

Taxodium has a spherical cone, when mature, with valvate rhomboidal scales. Sargent shows the young cone with imbricate scales and the crenate upper edge.

Sequoia Langsdorfii (Brgt.) Hr.

It is important to remember that, though there are *Sequoia* trees in California 3000 years old, it was not until the middle of last century that they were scientifically described as *Sequoia sempervirens* Endl., the Mammoth Tree or Redwood, and *Sequoia gigantea* Torr. or *Wellingtonia gigantea* Lindl., the Big Tree. At that time all fossils with foliage at all yew-like were called *Taxites*. Forbes in 1851 (56) named an Ardtun specimen *Taxites* (?) *Campbelli*. That this was not a mere guess, as Gardner states, is evident from the fact that Forbes noted its similarity to *Taxites Rosthorni* Ung. subsequently recognised as *Sequoia Langsdorfii* (Brgt.), the ancestral form of *S. sempervirens*. There are Ardtun specimens in the "Reed," "Koch," and "Currie" Collections in agreement with *Sequoia Langsdorfii* and Forbes's specimen. I have found similar foliage also farther north in the Islands

of Canna and Skye. There is a simple feature of generic value in distinguishing a leaf of *Sequoia* from one of *Taxus*. The leaf of *Sequoia* is always sessile and decurrent, that of *Taxus* stalked.[1] Owing to torsion or a "half-turn" the leaf of *Sequoia* (and the smaller sessile decurrent leaf of *Taxodium*) sometimes appear stalked and are so occasionally incorrectly described. Where leaf-tissue is available there should be no difficulty in distinguishing the three genera from one another. Restored tissue from Skye and Canna confirmed the reference of the fossils to *Sequoia Langsdorfii* and not to *Taxus*.

Mason hesitates to keep *Sequoia Langsdorfii* (Brgt.) Hr. distinct from *S. sempervirens* which he traces backwards into the Pliocene of W. America. *Sequoia* was widely distributed throughout the Northern Hemisphere, especially during the Oligocene. *S. gigantea*, however, is not recorded in the fossil state from W. America. This absence Mason accounts for on ecological grounds. *S. sempervirens* is now confined to the "fog-belt" of the Pacific coast and 30 miles inland. One assumes a similar mild wet habitat for *S. Langsdorfii*. *S. gigantea*, on the other hand, thrives on the arid western slopes of the Sierra Nevada, on the banks of rapid mountain streams not lending themselves to deposits. It is interesting to note that the fossil ancestor of *S. gigantea*—*S. Couttsiae* Hr.—of Bovey Tracey is well represented (58) in the Irish Tertiary but is unknown in Scotland.

Podocarpus eocenica Ung.

Podocarpus is now as pronouncedly confined to the Southern Hemisphere, "forming a girdle round it," as *Pinus* is to the Northern. In the "Currie" Collection from Ardtun there is a leaf which agrees with *P. eocenica* Ung. of Central Europe (Pl. XV, fig. 2). It shows on its underside two broad bands parallel to the midrib, especially well after moistening, when, under magnification, the individual stomata can be observed. Spite of this clearness attempts to obtain tissue failed. The leaf was brought to light by removal of the overlying *Ginkgo* leaf. As far as exposed it is 5 cm. long and 6–7 mm. wide, with a correspondingly thick midrib more than 1 mm. wide, slightly curved, the leaf being scimitar-shaped, linear.

[1] Mason gives a photographic illustration of *Taxus* sp. from Oregon, showing the petiole—the only case I know (Pl. I, fig. 4, W. Amer. Conifers, Contribs. Carnegie Instit., 346, 192).

There are many records of the occurrence of *Podocarpus* in the Cretaceous and Tertiary of Central Europe, etc., but many of these have been discarded and doubt thrown on others by Florin (58), who discovered that a fossil from the lignite of Saxony so named was in reality a Dicotyledonous leaf of unknown affinity. Seward and Holttum found "some rather poor specimens" in the Tait Collection agreeing with some better preserved ones Gardner had named *P. Campbelli*. They leave the question of its identity with *Podocarpus* open. This Ardtun record is one of the few Florin is inclined to accept, subject to confirmation, which the "Currie" specimen, I think, provides. J. B. Simpson (59) provides confirmatory evidence by the discovery of pollen-grains of *Podocarpus* in the interbasaltic lignite of Mull. The higher ground of tropical Africa is the nearest locality in which the genus now grows.

P. eocenica Ung. is allied to *P. falcata* R. Br. and *P. Thunbergii* Hook of S. Africa, to *P. chilina* and *P. nubigena* of S. America. In the absence of tissue the possibility of affinity of the fossil with *Cephalotaxus* of E. Asia, etc., e.g. *C. drupacea*, must not be overlooked.

MONOCOTYLEDONS.

Araceae.

Pistia Inglisi sp. nov.

Pistia Stratiotes L. is a floating aquatic Aroid of both hemispheres, frequenting tropical and sub-tropical waters and reaching Egypt by way of the Nile. It is characterised by an obovate roundish or elliptical leaf with a somewhat depressed or retuse apex, a basal tuft of hairs, and fine adventitious roots by means of which it fixes itself in the mud, as occasion requires. It develops also in its basal region a spongy parenchymatous cushion or intumescence which gives it its buoyancy. The lamina is traversed by some five main veins radiating from the base upwards. The three inner veins fork and all five are lost to view in the dense substance of the leaf in the apical region. By soaking a leaf in xylol it is possible to see these main veins and the interconnecting finer reticulum of veins. Unless my interpretation is wrong such a leaf as this was found near Portree in the Isle of Skye

in a Tertiary bed, discovered by Mr. Inglis. This change in geographical distribution is not more surprising than that of the fern *Dipteris conjugatoides* sp. n. of Co. Antrim, now in almost identical form growing in the Malay Peninsula.

The Skye fossil, *Pistia Inglisi* sp. n., is a fairly definite body, rounded to obovate in outline, 3×3 cm. in extent, with an emarginate or depressed apex. At first sight the vascular system has an indefinite, nondescript appearance. Further examination reveals the presence of several main veins, forking and fusing with the intervening network and radiating upwards. At the basal end of the fossil there is a layer of jet-like lignite, 1 mm. thick, in which delicate branching threads are embedded. This I interpret as the intumescence and group of adventitious roots of *Pistia*. Attempts to obtain tissue gave nothing of diagnostic value (Pl. XII, fig. 5).

Lesquereux (61) was the first, in 1874, to record a fossil *Pistia*. In his species, *P. corrugata*, Lesquereux saw a generic but not a specific likeness to *P. Mazeli* Sap. et Mar., from the Upper Cretaceous of Fuveau in Provence of which Saporta (62) had sent him particulars. In the same year Heer (63) described a leaf from the Upper Cretaceous of Greenland as *Chondrophyllum Nordenskiöldi* which was later transferred by Berry (64) to *Pistia*. The Skye leaf shows marked similarity in its vascular system to *P. Wilcoxensis* Berry of the Lower Eocene of Louisiana. In this leaf Berry describes the venation as "entirely of a single calibre, fasciculate-flabellate, forming by repeated and somewhat irregular cross-branches, an open polygonal mesh," a description which applies equally well to *P. Inglisi* and is the cause of my so naming the fossil (text-figs. 7 and 8).

LILIACEAE.

Smilacites grandifolia Ung.

The scarcity of Monocotyledons in the fossil state makes the presence in the Ardtun beds of a leaf which recalls the one named *Smilacites grandifolia* Ung. (65), from Croatia, of distinct interest. It is possible, by combining the characters of the incomplete specimens of the leaf found in three different collections from Ardtun, to obtain a good idea of its general features (Pl. XII, figs. 1–4). It varied in size from

6–11 × 4–6 cm.; was cordate- or ovate-hastate in shape, with pronounced auricles and a well-developed acuminate apex. (The apex is missing in Unger's type specimen of *S. grandifolia*, and in subsequent illustrations (restorations?) is shown as blunt and rounded.) The straight "midrib" is accompanied by 4 or 5 pairs of lateral (primary) nerves of the same strength as the midrib. They all take a curved ascending course, but only the innermost pair is truly acrodrome, passing, with the midrib, into the leaf-tip. The other pairs are more curved and less ascending the more external they are in their course. The innermost pair of veins does not arise at the leaf-base, at the point of entrance of the midrib, but some distance above it, so that this pair is not, strictly speaking, primary but secondary in nature. Unger's type specimen shows a similar origin for this pair, but in other illustrations a basal origin is shown, without comment on this difference by writers. The thick parenchyma of the coriaceous substance of the leaf, according to Unger, obscured the general venation, so that the primary veins only were observable in his type specimen. As the photographs show, the Ardtun material reveals the arrangement of the veins of higher order. The lateral veins are connected with one another and with the midrib by ladder-like, sub-horizontal vascular trabeculae or cross-anastomoses. The lamina is thus partitioned into a series of quadriform meshes, visible to the naked eye. Under magnification the ultimate vascular reticulum within these meshes is recognisable in places. This general type of venation agrees better with that found in the leaf of *Tamus communis* and other *Dioscoreaceae* generally. In *Smilax*, in most of the species I have examined in the herbarium of the Royal Botanic Garden, Edinburgh, there is a marked difference. The veins connecting the laterals with the midrib run obliquely upwards and downwards, making a sharp angle with these primaries. The quadriform meshes are not formed. The difference in the two forms of venation is clearly observable in the leaves of *Smilax aspera* L. and *Dioscorea versicolor* Wall., as figured by Schenk (66). The Ardtun leaf agrees in its primary venation with Unger's *Smilacites*, but in its well-preserved finer venation it is Dioscorean. Hence the question arises as to the justification for the reference of Unger's leaf to the *Smilax* group. It is

recorded from many localities, and in some cases in which the finer venation is indicated it is not Smilax-like. In *Smilax bona-nox* L. of Atlantic N. America, however, the finer venation is not unlike that of the Ardtun leaf. It is unfortunate that so far no leaf with leaf-stalk preserved has been found. A leaf-stalk with tendrils would be a decisive *Smilax* indicator. J. B. Simpson (68) figures as *Smilax*? sp. a pollen-grain he obtained from both the infra- and inter-basaltic beds of lignite of Mull. Hence it is better for the present to leave the Ardtun fossil under the name *Smilacites grandifolia* Ung.

DICOTYLEDONES.

SALICACEAE.

Populus portreeensis sp. nov.

This large suborbicular leaf must have been 20×20 cm. in extent. The midrib is thick, 2 mm. in diameter, and the rest of the venation relatively thin. The secondaries arise at an angle of 30°, increasing basipetally to 60° or more. They are curved, ascending, alternate, as much as 3 cm. apart and 11 cm. long. They give off tertiaries on their underside and are connected by mostly transcurrent cross-anastomoses. The ultimate reticulum forms polygonal meshes. The leaf surface is minutely tubercled, but not uniformly so. Restoration of tissue failed to reveal the nature of the persisting tubercles—whether fungal pycnidia or glands. Unfortunately base, apex, and edge are all missing. The general characters of the fossil suggest a leaf of *Populus*, but larger than any European one (text-fig. 9). Examination of herbarium material supplied a comparable leaf (69) in *Populus lasiocarpa* Oliv. of W. Hupeh, China, 19×15 cm. in size (text-fig. 10). This is a member of the section *Leuce* Duby which includes the largest leaf in N. America, *Populus heterophylla* L., and our *P. tremula* L. *P. balsamoides* Hr. of the Swiss Tertiary and *P. graeca* Ett. are also suggestive.

There has been considerable interchange or confusion in the past in fossil identifications between *Populus* and *Ficus*. Thus Lesquereux's *Populus monodon* is transferred to *Ficus* by Berry, to be restored by later writers to *Populus*.

The rigid idioblasts which give a dried *Ficus* leaf a tubercled

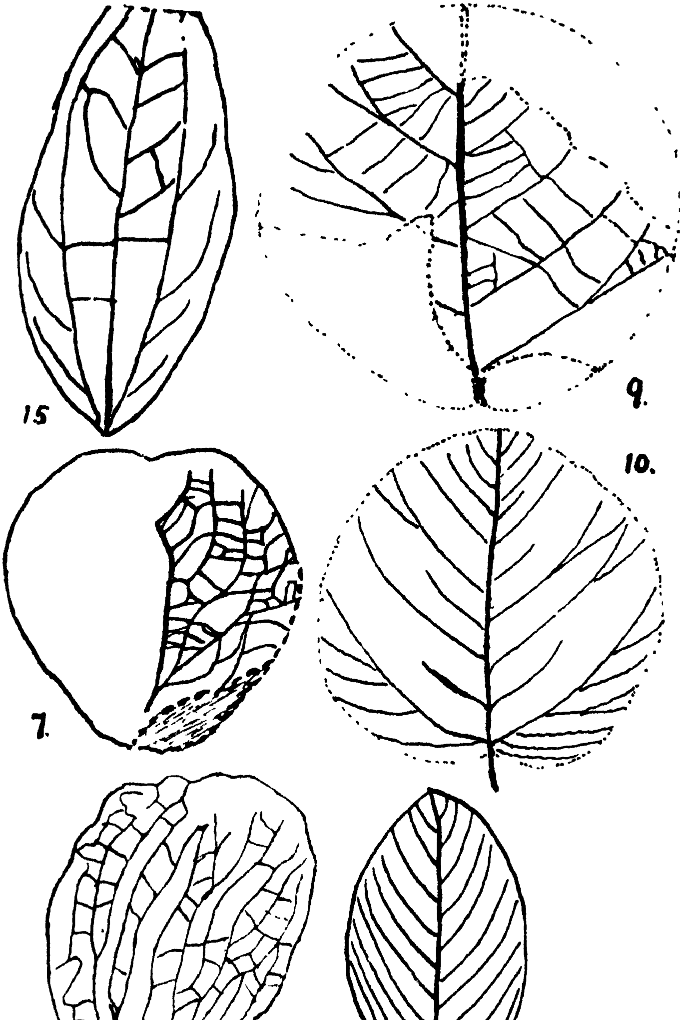

Fig. 7.—*Pistia Inglisi.* (× 1.)
Fig. 8.—*Pistia Wilcoxensis.* (× 1.)
Fig. 9.—*Populus portreeensis.* (× $\frac{1}{4}$.)
Fig. 10.—*P. lasiocarpa* Oliv. (× $\frac{1}{4}$.)
Fig. 14.—*Berchemia Wilsoni.* (× 1.)
Fig. 15.—Diagram of *Zizyphoides ardtunensis.* (× 1.)

surface would be lost in restoration of the leaf by the maceration method.

It is worthy of note that alongside the fossil *Populus* from Skye is a scrap of *Sequoia Langsdorfii*. These two genera grow side by side in California now.

Salix Finlayi sp. nov.

It is surprising that the swampy site at Ardtun which yields *Onoclea* and *Equisetum* in plenty should show little reliable trace of the presence of the willow.

Of two or three leaves in the collections from Ardtun the one illustrated seems most suggestive, as it shows, as far as traceable, many of the features characteristic of a *Salix* leaf (Pl. XIII, fig. 5 and text-fig. 11).

It is an oval leaf, 6×2 cm. in extent, short-stalked (stipulated?). From the slightly curved midrib arise some 10 to 12 pairs of camptodrome, curved secondaries at an angle of 45°–60°, as much as 9 mm. apart, with intervening abbreviated secondaries, connected with the adjacent secondary. The branched cross-anastomoses and, in places, the ultimate vascular polygonal reticulum are observable. The fossil shows general agreement with *Salix Raeana* Heer of Mackenzie River (65° N.), and Atanekerdluk in Greenland (70). Amongst living species *Salix canariensis* Sm. of the Canary Islands is suggestive. Heer pointed out that the majority of the European Tertiary willows are members of the group *Gymniteae* which includes *S. canariensis* of the Canary Islands, and certain tropical and S. African willows, the earliest to appear, and connecting *Salix* with *Populus* through the narrow-leaved members of the Balsam poplars.

Betulaceae.

Betula cuspidens Sap.

The birch tree, *Betula* L., though recorded from several localities in N. America and West Greenland in the Upper Cretaceous does not appear in Europe until the Tertiary. It occurs in the Paris Basin in the early Eocene. One of the best preserved leaves at Ardtun fills the gap in distribution between Greenland and France and supports the view of the

existence of a connecting North Atlantic land-bridge. This leaf is 10 × 4 cm. in extent, ovate-lanceolate in outline, with an acuminate apex, and tapering base (Pl. XIII, fig. 1). There are at least 12 pairs of well-marked, more or less straight craspedodrome secondaries, opposite below, alternating apically, parallel to one another, and 5–7 mm. apart. They come off at a sharp angle, usually 30°. The cross-anastomoses are pronounced, transcurrent or branched and connected with the ultimate vascular reticulum, well-preserved in places. The edge of the leaf is biserrate. The tertiaries are inconspicuous, and like the secondaries enter the marginal teeth. Attempts to obtain tissue of any diagnostic value failed. This leaf is so like *Betula cuspidens* Sap. (71) of the Upper Oligocene of Armissan, S.E. France, that I propose to apply this name to it. *Betula Wilsoniana* C. Schn. of China (Hupeh ?) and *B. lenta* L. of East N. America are living species of the same type. *B. alba* (*B. verrucosa* Ehrh.) and *B. pubescens* Ehrh. are later arrivals in the British Flora and of different type.

In the absence of tissue and fruits the possibility of confusion with *Carpinus* and *Ostrya*, whose leaves are very similar, must not be overlooked. A detailed comparison of the edges of leaves of the three genera seems to justify the reference of the Ardtun lead to *Betula*.

Corylus MacQuarrii (Forbes) Heer.

Corylus Avellana L., the hazel, occurs in the British Isles as far north as the Orkneys and is one of some ten species of the genus confined to the North Temperate Zone. One of the fossils found at Ardtun was named by Forbes (72) *Alnites* (?) *MacQuarrii*, a name changed by Heer (73), after inspection of the type specimen and re-drawing, to *Corylus MacQuarrii*. Investigation indicated that this species was one of the most widely distributed forms in the early Tertiary in the Arctic regions, from Sakhalin in the East to Alaska in the West. It was evidently plentiful at Ardtun and there are many fine specimens in the Hunterian Museum, the Glasgow City Museum, and the Royal Scottish Museum, Edinburgh. Seward and Holttum (74) in their revision of the Ardtun flora decided to leave Forbes's fossil with the name he gave it, as

their examination of the type failed to satisfy them as to its affinity. They, however, found in the Tait material leaves which they name *Corylites hebridica*, including in it Gardner's leaf of *C. MacQuarrii*, as figured, "undoubtedly identical." Had they seen any of the collections I have mentioned they would, I think, have hesitated to create their new species on such incomplete material as their figures show. The emarginate cordate base is clearly marked in all specimens of *C. MacQuarrii* (Pl. XIV). It occurred to me that the asymmetrical semi-cordate base of the type, as drawn, was artificial. I was allowed to remove a piece of the overlying rock, to find, on doing so, the hidden portion of the base, showing it was really symmetrical, cordate, and emarginate. A little tissue was obtained, revealing cells with wavy walls as in *Corylus*, as well as a typical sclerotic hair. Heer was, I consider, justified in his opinion.

The name *Corylites hebridica* S. et H. should not be applied in general to forms hitherto named *C. MacQuarrii* but confined, if retained, to the particular material described. The Heddle Collection, from the Isle of Canna, contains a sample of *C. MacQuarrii*. Saporta (75) made the interesting observation that *C. MacQuarrii* represented certain living species in East Asia which serve as a connecting link between *Corylus* and *Carpinus*. It is nearer *C. Colurna* of S. Europe, than to our *C. Avellana*. It is a striking example of the passage through the British Isles southwards in the course of time of species of northern (Arctic) origin. Schneider considers it possible to distinguish the various species of *Corylus* both by their nuts and leaves. It is of interest to note that J. B. Simpson (77) discovered pollen-grains in the various deposits of lignite from Mull, he examined and referred some provisionally to *Alnus*, others to *Corylus*, noting at the same time the claims of other members of the great group of *Amentiferae*.

FAGACEAE.

Castanea.

Castanea, the Spanish chestnut, has much the same distribution in the extant floras as *Eu-Fagus*, but is of a more markedly southerly type. It is (*e.g.*) not indigenous, like *Fagus*, in the British Isles or Scandinavia. It occurs in S. Europe,

N. Africa, Asia Minor, E. Asia, S.E. North America, under various specific names which Schneider considers may in part, perhaps, indicate geographical varieties of one common species. Unger (78) named a fossil leaf, from Leoben in Styria, *Fagus castaneaefolia.* He was satisfied it was really a *Castanea* leaf, but in accordance with the prevailing custom refrained from the use of that name as fossil fruits of *Fagus* but not of *Castanea* were known. Heer described similar leaves from the Arctic regions under the name of *Castanea Ungeri* (replacing Unger's). He distinguished *C. Ungeri* from *Quercus groenlandica* Hr., by its edge with sharp more or less cuspidate teeth, those of *Q. groenlandica* being rounded and blunt, a distinction Heer kept in mind throughout the seven volumes of his *Flora Arctica.* He supports his reference of the leaves to *Castanea* by the discovery of the male flowers and fruits of the genus at Atane in Greenland, a locality which had yielded leaves. In their discussion of the reliability of the reference of the leaves to *Castanea,* Seward and Holttum (79) overlooked Heer's illustrated account (80) of the fruits of *Castanea.*

Castanea dentoides sp. nov.

Pl. XIII, fig. 4 represents a nearly complete leaf from Ardtun. It was oblong-ovate, 8 × 4·5 cm. in extent, with an attenuated cuneate base, and apparently acute apex. The edge, where preserved, shows single, sharp, subcuspidate teeth, with shallow intervening sinuses. The stalk is 1 cm. long and expanded at its base of attachment to the stem. There are some 18 pairs of secondaries opposite or sub-opposite, arising at an angle of 40° generally, slightly arched, parallel to one another, 3–4 mm. apart, unbranched and craspedodrome. There is practically none of the substance of the leaf left. Here and there, especially after moistening, the cross-anastomoses and polygonal meshes of the ultimate vascular network are recognisable as impressions in the stone matrix and agree with those of *Castanea.* In its cuneate base and venation the Ardtun leaf suggests the American species *C. dentata* Bkh. rather than the European species *Castanea castanea* Karst (*C. vesca* Gaert.). The general features are not unsuggestive of the Arctic leaf Heer named *Quercus Olafseni,* but the edge in it is bidentate and the teeth blunt.

MAGNOLIACEAE.

Magnolia Inglefieldi Hr.

Actual specimens proving the presence of *Magnolia* at Ardtun are, I think, not known. Gardner (81) says vaguely: "Among the large leaves in the clays (at Ardtun), seen but not collected, appeared to be forms like those described from Atanekerdluk as . . . *Magnolia Inglefieldi* Hr." I give a photograph of a leaf from Skye which I regard as this species (Pl. XV, fig. 3). It is a simple stalked leaf, elliptical in form, 12×5 cm. in extent with thick midrib and 7–8 pairs of curved camptodrome alternating branched secondaries making an angle of 50° with the midrib. They are distant, being as much as 2 cm. apart. Abbreviated secondaries are observable. The cross-anastomoses and ultimate vascular reticulum of polygonal meshes are not pronounced. The edge appears entire. The Skye leaf is very similar to the one figured by Heer (82) from Atanekerdluk (Pl. XVIII) as *Magnolia Inglefieldi*, closely allied to *M. grandiflora* of southern N. America. There is considerable difference of interpretation of *Magnolia*-like leaves in America. Some are assigned to *Magnolia* by certain authorities and by others to *Terminalia*. *M. hilgardiana* Lesq. is, for example, transferred by Berry (83) to *Terminalia*, to be placed again by Chaney (84) in *Magnolia*.

J. B. Simpson's discovery of pollen-grains (85) of *Magnolia* in both the infra- and the inter-basaltic lignite of Mull lends support to the reference of these leaves to that genus.

MENISPERMACEAE.

Protophyllum Barclayi sp. nov.

One of the most interesting and puzzling leaves from Ardtun, collected by Dr. T. Barclay, is illustrated on Pl. XVI, figs. 1, 2. It is an incomplete specimen of a large leaf, probably 12 cm. long and broad, of coriaceous texture. The midrib is very thick and from it arise at an angle of 60°, increasing basipetally to 90° or more, some 10 pairs of alternating secondaries, running parallel to one another and giving off few tertiaries, so far as traceable. Abbreviated secondaries are rare. Edge and apex are missing. The cross-anastomoses, straight and arched, branched and unbranched,

are well developed. The ultimate reticulum (Pl. XVI, fig. 2) consists of quadriform meshes with blind endings, often observable in their centre. This type of venation is present in *Liriodendron* in the *Magnoliaceae* and in the *Menispermaceae*, etc. The Ardtun leaf is very similar to a leaf from Greenland collected and named by Seward (86) *Menispermites Nordenskiöldi*. L. Diels, to whom I sent a sketch of the Ardtun leaf, was unable to suggest its affinity but said it was certainly not one of the *Menispermaceae* (which he had monographed (87)). It has many points in common with the leaf named *Protophyllum multinerve* Lesq. from the Cretaceous of Kansas (Dakota group).

Comparison may also be made with *Dicotylophyllum Gaudini* (Hr.), under which name (88) Seward and Conway place the leaves[1] from Greenland described by Heer as *Populus Gaudini* (?) and *P. stygia*. The finer venation is not indicated.

Unfortunately the Ardtun leaf is basally incomplete. It shows the trans-petiolar extension of the lamina, but it is impossible to decide whether the base is sub-peltate or simply cordate emarginate. As a non-committal name *Protophyllum Barclayi* seems appropriate.

HAMAMELIDACEAE.

Hamamelis suborbiculata sp. nov.

The witch-hazel family, the *Hamamelidaceae*, is represented by several leaves in the Ardtun Tertiary. The leaf photographed (Pl. XX, fig. 4) is 9·5 cm. × 8 cm. as preserved, with a rounded form and acute apex. Like the living leaves of the genus the fossil is asymmetrical, with 6 or 7 pairs of alternating secondaries which make angles of 70°–50° with the curved midrib in the lower part of the leaf, of 50°–60° in the apical region. The lower secondaries are, as in the living leaf, camptodrome, the upper craspedodrome. The edge is sinuous below, becoming sinuous-dentate apically.

[1] Heer's name *stygia* seems more appropriate. In his vol. i, Heer describes the Disco leaves under *P. Gaudini* Fischer with a query, doubting their agreement with the Swiss leaves so named. In his vol. iii (p. 10) he says these leaves probably belong to *P. stygia* and to the Cretaceous, not the Tertiary. He repeats this opinion in vol. vi, p. 64.

Tertiaries are given off from the proximal side of the lower secondaries. The cross-anastomoses are pronounced, simple or branched, at right angles to the secondaries and with less conspicuous veins at right angles to them. Some tissue of the upper epidermis was obtained. The cells are polygonal, with mostly straight lateral walls and a striate surface. The genus *Hamamelis*, to which I refer the Ardtun leaf as *Hamamelis suborbiculata* n. sp., is represented by two species in the New World and two in China and Japan. *H. mollis* Oliv. of China (Hupeh) (89) stands near the fossil. The early appearance of the family is indicated not only by the fossil records from America and Europe, but also by the wide discontinuous distribution of the many genera, each of a few species.

Cercidiphyllum crenatum Brown comb. nov.

A chronological record of the changes in synonym of this interesting fossil leaf seems desirable as its history is an involved one. In 1850 Unger published a brief description (90) of a fossil leaf which he named *Dombeyopsis crenata*, with an acknowledgment to Heer for a description of a Swiss specimen of it. In 1855 Heer gave a figure of it (91) badly infested with a fungus he called *Xylomites maculifer*. Next year he gave an elaborate illustrated account of *Populus* L. with a detailed description of living species, and of eight fossil species and their varieties. Under one of these fossils, *Populus glandulifera* Hr., he showed a figure (92) of a leaf markedly different from the other figures of this species but made no mention of the figure in the descriptive text. The leaf figured (Pl. LXIII, fig 7) agrees with *Dombeyopsis crenata* Ung. in detail. In 1859 Heer (93) transferred *D. crenata* to *Grewia* on the ground that Unger's *Dombeyopsis* had craspedodrome secondaries and those of his fossil were camptodrome. It was with some misgiving that he chose *Grewia*, as other named genera had a venation not unlike that of *G. crenata*. He supported the transfer to *Grewia* on the ground that he had found *Grewia*-like fruits though from a different Swiss locality.

In 1868 Heer described in his first illustrated account (94) of the fossil flora of the Arctic regions three species of *Populus* —*P. Zaddachi*, *P. Richardsoni*, *P. arctica*. He had already in 1859 named and recorded *P. Zaddachi* as the commonest

tree in the Aquitanian (Oligocene?) amber beds of Samland (95). These three Arctic species had, in common with the fossil *Grewia*, palmate venation, consisting of 5–7 primary basal veins of which the three inner are more or less acrodrome. In this type of venation Heer noted their difference from all previously known living and fossil *Populus*, justifying their inclusion by regarding them as representative of an extinct section of the genus, an unreliable assumption as it proved to be.

In 1876 Heer recorded (96) the occurrence in Spitzbergen of the Swiss form, *Grewia crenata*, as well as of *G. crenulata* (with edge, apparently entire to the naked eye), and *G. obovata* with crenate edge and more or less cuneate base. He repeated his doubts about the reference of the *Grewia* fossils to that genus, as the fruits he had assigned to it were now considered (and admitted by him to be) *Celtis* in character. He added that the leaves reminded him strongly of *Cercidiphyllum japonicum*, a fruitful suggestion on his part. Heer also noted the likeness of *Populus Zaddachi* to *Grewia crenata*. He based the distinction mainly on the leaf edge, stating that in *Grewia crenata* the crenate margin possessed glandless teeth while in *Populus Zaddachi* the more pointed forward-directed teeth were glandular. These glands are clearly indicated in many of Heer's figures. I shall have occasion to return to this supposed difference. Fossil leaves also showing palmate venation had been found in N. America, and in 1874 Lesquereux (97) named one of these *Phyllites rhomboideus*, distinguishing it from *Populus arctica* Hr. by a difference in the base.

In 1887 Gardner gave an illustrated account (98) of an Ardtun leaf he named *Boehmeria antiqua*, regarding it as possibly identical with a living Japanese species of that genus. In their revision of the Mull Flora, Seward and Holttum simply listed this and *Grewia* as Gardner had recorded them, as there were no Mull specimens known to them. These and many others are to be found in the various collections I mentioned in an account (99) of the Mull and Canna floras communicated to the Aberdeen meeting of the British Association in 1934. I showed then that *Boehmeria antiqua* Gardn. was simply *Grewia crenata* Hr. (Pl. XVII, figs. 1, 2), not recorded by Gardner, and that the Ardtun leaves he called

G. crenulata Hr. were Heer's *G. crenata*. At that meeting W. N. Edwards expressed the opinion, already in 1876 suggested by Heer, that *Grewia crenata* (Ung.) was a *Cercidiphyllum*. The question of identity, apart from venation, appears to depend on the nature of the leaf edge, on which no detailed statement has so far been made. I quote particulars from Solereder's Anatomy in trying to make good this omission. The leaf-edge of living *Grewia* L. is serrate and the teeth glandless. In *Populus* L. many living species have glandular teeth. The glands consist merely of epidermal cells and being superficial would leave no structural change in the appearance of the tooth in the fossil state. In *Cercidiphyllum* (100), on the other hand, the glands are emergences—multicellular cup-like depressions—seated asymmetrically on the tip of the crenate teeth, and containing a gummy secretion. Such a gland would leave its mark and be observable in the fossil state. In the photograph (Pl. XVII, fig. 1) a piece of the leaf edge of *Cercidiphyllum japonicum* is seen lying alongside a piece of the leaf edge of *Grewia crenata* Hr., from Ardtun, both under the same enlargement. The crenate tooth of the "*Grewia*" leaf is seen to show a broken outline as if a piece of the tooth substance had been scooped out. This I take to represent the cup-like glandular emergence of a *Cercidiphyllum*, justifying by its presence the view that *Grewia crenata* Hr. is an ancestral form of this East Asia genus. I have followed Heer's account of *Populus* in his Swiss and Arctic floras from 1855 to 1883. *P. Zaddachi* Hr. is the only species in which glandular teeth are described and figured. By them Heer distinguished *P. Zaddachi* from *G. crenata* as stated. Their agreement with those in the photograph is striking and clear evidence that *P. Zaddachi* does not, with certain associated species (*P. Richardsoni* Hr., *P. arctica* Hr.), represent an extinct section of *Populus* but is identical with *Cercidiphyllum* also. The proposed transfer (101) of these species of *Populus* and of *Grewia crenata* Hr. to *C. crenatum* seems fully justified.

It is difficult at times, in reading Gardner's account of the leaf-beds of Ardtun, to make out whether he has seen the species mentioned or is merely criticising Heer's views on it. Thus he stated (p. 291) Heer's two species *Populus Richardsoni* and *P. arctica* (from the Arctic regions) are "indistinguish-

able or seem to him to be so." There are no specimens of these species known from Mull and Gardner's opinion appears to be based on Heer's Arctic figures. The view attributed by Seward and Conway to Gardner that *Boehmeria antiqua* Gard. was regarded by him as generically if not specifically identical with *Populus arctica* seems incorrect. I can find no record of such a view. The doubts about Heer's Arctic species of *Populus* (and *Grewia*) first took concrete form when Berry (102) in 1920 transferred *Populus arctica* to a new form-genus *Trochodendroides* in which he placed *Phyllites rhomboideus* Lesq., though his specimen (restored) shows the rounded base usual in *Populus arctica* and not the cuneate base of Lesquereux's specimen, a feature which, Lesquereux stated, prevented him from naming it *P. arctica*. The name chosen by Berry is inappropriate as the living genus *Trochodendron* shows pinnate venation and the leaves under consideration, without exception, palmate venation. The *Trochodendraceae* is an ill-defined family. Part of it (three genera) is closely allied to the *Magnoliaceae*, in which *Tetracentron* is placed by Hallier, *Cercidiphyllum* being included in the *Hamamelidaceae* or given independent status as a family. The leaves of *Cercidiphyllum* and *Tetracentron* are so similar in venation, etc., that a common ancestry has been suggested (5) for them. There are, however, certain fundamental differences militating against this view. *Tetracentron*, like *Drimys* in the *Magnoliaceae*, possesses tracheides in its secondary wood, *Cercidiphyllum* vessels. Their inflorescences and flowers are also different. *Cercidiphyllum* is unique in having its "ventral" sutures directed outwards.

In their account of the fossil plants from West Greenland Seward and Conway supply many clear photographs which they name *Trochodendroides arctica* (Heer) Berry. In one case (Pl. IV, fig. 30) the glands are evident, I think. The name Dr. R. W. Brown was, according to Chaney's letter to Seward, about to publish for the transferred forms—*Cercidiphyllum crenatum*—seems more suitable and is here adopted. *Zaddachi* as a specific name is older than *arctica* and *Trochodendroides* as a generic name too vague. *Cercidiphyllum* furnishes a striking illustration of the change in geographical distribution in the course of time. It is now confined to certain mountains in Japan and China. It can be traced

under various synonyms throughout the Arctic regions as far north as Grinnell's Land (81° 46″) and from Sakhalin Island in the East to Alaska in the West, southwards through Oregon and British Columbia to Kansas and Texas in the New World, and in the Old World into the Isles of Skye and Mull, the Baltic Oligocene and the Swiss Miocene.

The discovery by J. B. Simpson of pollen-grains of five genera of the *Hamamelidaceae* (103) in the infra- or inter-basaltic lignite of Mull indicates that this family was well represented in the early Tertiary of Scotland.

C. crenatum (Ung.) synonyms dated:—

1850. *Dombeyopsis crenata* Ung.
1855. *Populus glandulifera* Hr. (pro parte).
1859. *Grewia crenata* Hr.
1859. *Populus Zaddachi* Hr.
1868. *Populus Richardsoni* Hr.
1868. *Populus arctica* Hr.
1874. *Phyllites rhomboideus* Lesq.
1876. Heer cf. *Cercidiphyllum japonicum*.
1887. *Boehmeria antiqua* Gard.
1920. *Trochodendroides rhomboideus* Berry.
1935. *Trochodendroides arctica* Seward and Conway.
(?) *Cercidiphyllum cuneatum* Brown.

PLATANACAE.

Platanus Kochi sp. nov.

The leaf photographed (Pl. XVIII, fig. 2) gives a good example of the difficulty of distinguishing between *Platanus* and *Acer* from fossil impressions only. Though imperfect it is clearly a three-lobed leaf, 5 × 4 cm. in extent, with a pronounced cordate emarginate base. One of the lateral lobes is well preserved and shows an acute apex. There are three primary veins. The two lateral primaries each make an angle of 40° with the midrib so that the central lobe is a narrow one. They and the secondaries, which are better developed on their outer (lower) side, are all craspedodrome and end in the teeth of the shallowly dentate edge. The lowest secondaries are horizontal and give off on their lower side tertiaries which end in the marginal teeth of the leaf-base. The cross-anastomoses are strong, run parallel to one another, and at right angles to

the larger veins. The polygonal vascular reticulum is well developed. The lowest pair of secondaries of the midrib

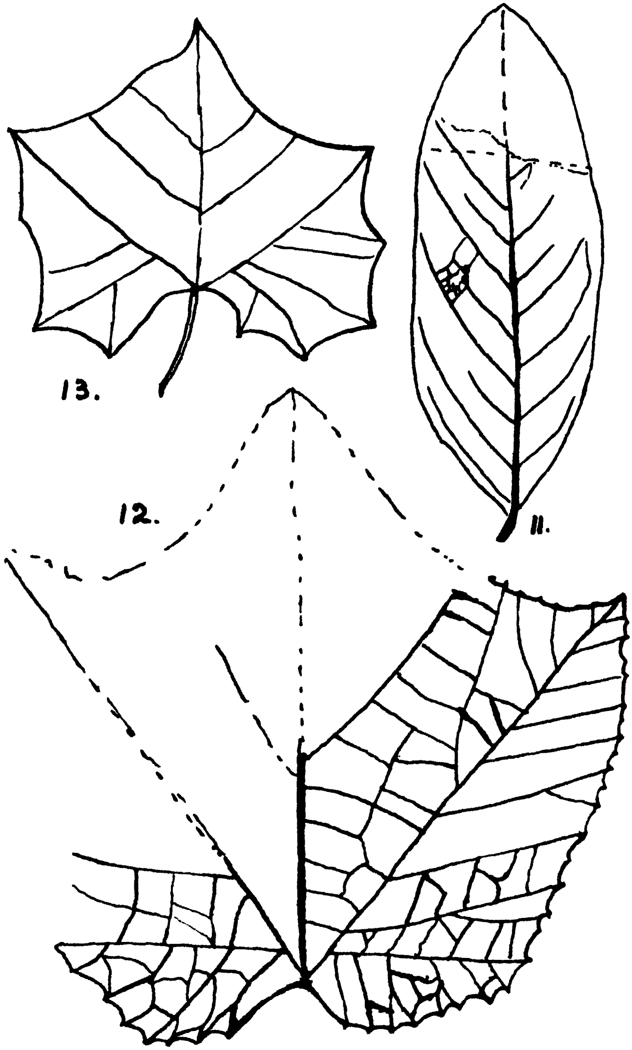

FIG. 11.—*Salix Finlayi*. (× 1.)
FIG. 12.—*Platanus Kochi*. Ardtun. (× 2.)
FIG. 13.—*P. occidentalis*. (After Henry.) (× 1.)

arise some distance above the point of origin of the three primaries at the leaf-base. They show no signs of forking, so

far as traceable. An unusual feature is the apparent forking of the lateral primary towards its distal end. I was inclined to leave this leaf in the genus *Acer* near *A. glabrum* Torr. and *A. spicatum* Lam. because of its cordate emarginate base. In general venation and dentate edge it suggests *Platanus* (text-fig. 12).

In his "History of the London Plane" A. Henry describes the base of *Planatus occidentalis* L. as cordate (his Pl. V, fig. 2), much as in the fossil, but with a more open basal sinus.

Platanites hebridicus (Forbes) has a very similar sinuous dentate edge.

ROSACEAE.

Amelanchier ovalis sp. nov.

Amelanchier Med. as a member of the *Pomaceae* is represented by 14 species in the North Temperate zone. Most of the forms are growing in North America from which 8 or 9 Tertiary species are recorded. Its present occurrence in the Old World also (e.g. *A. cretica*) suggests its circumpolar origin. A leaf (Pl. XIX, fig. 5) from Ardtun helps to fill in the gap in distribution between Central Europe and Spitzbergen to which Schenk calls attention. It is a simple broadly elliptical or ovate leaf, 6–7 cm. long, 4·5 cm. broad, with rounded base and apex. There are 7–8 pairs of sub-opposite curving, camptodrome secondaries, 1 cm. apart, arising at an angle of 35° from the midrib. The leaf-edge shows peg-like teeth but is not much indented. Tertiaries arise near the leaf-edge secondaries and form a marginal reticulum from which fine veins pass to the teeth. The fossil provides an excellent example of camptodrome secondaries accompanying a toothed margin. The finer venation is well preserved and consists of a network of veins, many of the meshes being more or less quadriform. The leaf, *Amelanchier Botryapium* DC. (104) agrees in size, shape, and venation with the Ardtun leaf. It occurs in Canada and Virginia. *Amelanchier ovalis* will serve to indicate the Ardtun leaf.

AQUIFOLIACEAE.

Ilex Ardtunensis sp. nov.

Fig. 3, *c*, on Pl. XVIII shows a simple, ovate-lanceolate leaf 2 × 1 cm. in extent, with 4 or 5 pairs of alternating secondaries

arising at an angle of 30°–40°, and curving upwards. Near the edge of the leaf they unite by branches or tertiaries to give rise to a marginal network. The edge of the leaf is obscure, but there is no sign of the continuous sub-marginal vein characteristic of a Myrtaceous leaf. Abbreviated secondaries are observable. The shape, venation, and other ascertainable features agree with those of a leaf of *Ilex* such as *Ilex crenata* Thbg. or *Ilex verticillata* (L.) Gray, both species of the Atlantic side of North America. Comparison may be made with *Ilex stenophylla* Ung. (106) of Styria. In this species with its modern representative *I. decidua* Walt., also of North America, the base is more attenuated than the Ardtun leaf which I name *Ilex ardtunensis*.

Alongside it, on the slab, is a stalked rounded body, 7 mm. in diameter, in the centre of which are two ridged seed-like bodies. I consider this to be a stalked crushed *Ilex* fruit. The holly berry is of the same size and contains four furrowed or ridged stones ("pyrenes") which are enclosed in the fleshy mesocarp, as in the fossil. The occurrence of leaf and fruit side by side though only in juxtaposition seems mutually confirmatory of *Ilex* identity. The leaf of the holly, *Ilex Aquifolium* Hr., gives an inadequate idea of the leaf of the genus as a whole. Most of the species (some 300) are without a spinous edge. Many have an entire margin with camptodrome venation. The family has a wide distribution in the warmer and temperate regions of the world and is reliably recorded from the Oligocene amber beds of the Baltic region.

RHAMNACEAE

Rhamnus.

In 1851 Forbes published in his brief note on the fossil leaf-beds of Ardtun figures, prepared by W. H. Baily, of three leaf-fragments which he placed, with one or two queries, in the genus *Rhamnites* (108) giving each leaf a specific name, but without description. In their Revision (109) of the Ardtun beds, Seward and Holttum place these forms in *Phyllites*, suggesting that *R. multinervatus* may be an unexpanded leaf of *R. major*. In the various collections that have come to light since the Revision I have found almost perfect specimens of the three types of leaves from which more definite conclusions can, I think, be drawn.

Rhamnus lancaeformis (*Rhamnites* (??) *lanceolatus* Forbes).

Forbes's specimen consisted of the basal part (one-third only of its length) showing only 4 pairs of alternating secondaries. The leaf photographed (Pl. XIX, fig. 1) is almost complete in outline, 5·5 × 1·3 cm. in extent, clearly lanceolate with acute apex, and attenuated base. The edge appears entire. There are some 11 pairs of alternating camptodrome secondaries, 3–4 mm. apart, and set at an angle of 40°–45° with the midrib and connected by oblique cross-anastomoses, clearly marked, as is the ultimate vascular reticulum of polygonal meshes in places. No tissue was obtainable. A *Rhamnus lanceolatus* Pursh was described in 1814, unconnected with this fossil. *R. lancaeformis* might in consequence be a convenient name for the fossil. Comparison may be made with *Alphitonia excelsa*, an Australian member of the family in which Ettingshausen sees a likeness to an American *Rhamnus*. *Rhamnus comentellus* Benth. of the Pacific side of North America (S. California to Arizona) is not unlike *R. lanceolatus* Forbes.

Rhamnus multinervatus (Forbes).

An almost perfect specimen of this species is figured (Pl. XIX, figs. 2, 3). The leaf is oval-lanceolate, 4·5 × 2 cm. in extent, with base and apex somewhat attenuated. There are some 12 pairs of camptodrome secondaries, 2–3 mm. apart, arising at an angle of 40°–30°. The leaf-edge is entire. The lower pairs are opposite, the upper alternating. The cross-anastomoses are oblique.

The fossil leaf is not unlike one of the leaves of *Berchemia multinervis* A. Br. figured by Heer (110), differing from it in its attenuated base and apex. There is a variety of *R. Frangula* L. itself, highly suggestive of the fossil.

Rhamnus major (Forbes).

An almost perfect example of this type is illustrated (Pl. XIX, fig. 4). It is an elongated ovate-lanceolate leaf, 10 × 3·5 cm. in extent, with entire edge and 13–14 pairs of alternating camptodrome secondaries, making an angle of 45° with the midrib, 5–7 mm. apart. The cross-anastomoses are sub-horizontal, making an oblique angle with the secondaries. The ultimate vascular reticulum of polygonal meshes is evident in places. The feature of special interest is the

presence of a prolonged acuminate apex, suggestive of a drip-tip. *R. major* Forbes recalls *R. latifolius* L'Hér. of the mountain forests of the Azores and Madeira, and, except in apex, *R. Frangula*. The fossil *R. deletus* Hr. of the Swiss Miocene is also suggestive, as is *R. Gaudini* Hr., a species common to Greenland and Europe, with toothed edge, however.

The early appearance of the buckthorn family is indicated by the geographical distribution of the extant genera, in islands long isolated and other relict localities. Schneider considers the herbarium material available for the determination of the characters of the 100 living species of *Rhamnus* is insufficient, a view to be kept in mind in the investigation of fossil members of the genus. Curved camptodrome secondaries with more or less horizontal cross-anastomoses, obliquely inclined to the secondaries, are features common to extant and extinct forms. In the absence of fruits the leaf determination must be provisional.

Berchemia Wilsoni sp. nov.

One of the fossils found near Loch Fada in Skye by Mr. G. O. Wilson is a *Rhamnus*-like leaf, not suggestive of *Rhamnus multinervatus* of Ardtun. It is an oval leaf, 4 × 2 cm. in extent, with a thick midrib, slightly curved apically (text-fig. 14). There are some 9–11 pairs of alternating unbranched secondaries, 3–4 mm. apart, arising at an angle of 30°, increasing basipetally to 50°, parallel and curving upwards a little, camptodrome. Edge is apparently entire. The cross-anastomoses are not so pronounced or conspicuous as shown in some figures of *Berchemia multinervis* (Hr.) to one form of which the fossil is not unlike. It appears to be connected with *Berchemia volubilis* L., a climbing shrub of Florida, Virginia, and Carolina.

Heer gives numerous figures of *B. multinervis* in his Swiss flora. The one selected for illustration by Schenk represents an extreme form. The Skye leaf appears intermediate in character between this form and the leaf figured in Unger's *Chloris*.

Zizyphoides ardtunensis sp. nov.

In the Ardtun collections examined there are several specimens of the type of leaf found in *Zizyphus* or *Paliurus*.

One of these (Pl. XX, fig. 1 and text-fig. 15) is a simple, ovate-elliptical leaf, twice as long as broad (6 × 3 cm.), tapering basally and apically. There are three or possibly five main basal veins, the two (inner) lateral making an angle of 20° with the midrib, and taking an ascending course to form a loop with obliquely arising secondaries connected with the midrib at about two-thirds of the length of the leaf from the base. There are other similar pairs of alternating secondaries. From the outer side of the two outer basal nerves tertiaries are given off at intervals at an angle of 55°. These take a curved ascending course to merge into a marginal reticulum. The edge is obscure, suggesting teeth at one or two places. The ultimate vascular reticulum consists of polygonal meshes. Attempts at restoration yielded a little tissue in which stomata were found. The possibility that the "obscure edge" is really the delicate outer pair of basal veins must not be overlooked. The difficulty of distinguishing between leaves of recent species of *Zizyphus* and *Paliurus* is increased in the case of fossil leaves. Seward and Conway have proposed (111) the name *Zizyphoides* for leaves that may belong to either genus, and they have referred *Paliurus Colombi* Hr. to this though Heer found a half fruit (*Paliurus*-like) and a thorny twig alongside the leaf, as indicative evidence of its generic affinity. Gardner expressed the view, probably based on Heer's earliest account, that *Paliurus borealis* and *Zizyphus hyperboreus* were one and the same species. A comparison of Heer's figures and descriptions of these in his last volume on the Arctic floras shows how different the two are.

Combretaceae.

Terminalia magnoliaefolia sp. nov.

One of the finest leaves found at Ardtun is that illustrated in Pl. XXI, fig. 2. It is an incomplete broadly oval leaf, 16 × 8 cm. in size, more attenuated basally than apically apparently, and probably of a coriaceous texture. The midrib is thick and curved somewhat. There are some nine pairs of curved camptodrome, alternating secondaries, making an angle of 50°–40° with the midrib. They are very thick and connected with one another by well-pronounced

straight and branched cross-anastomoses making branching of the secondaries or formation of tertiaries unnecessary. In places the ultimate vascular network with small meshes is preserved. The edge was apparently entire though it is difficult to make it out, partly owing to the curvature of the leaf surface. The arching of the secondaries near the leaf-edge is observable in the apical region of leaf (on right side of photograph). No tissue was obtained except isolated club-shaped pointed black hairs of the size and shape found in the family *Combretaceae*. The leaf agrees perfectly with that from Radoboj in Croatia named *Terminalia radobojensis* Ung. (112). There are several similar leaves recorded from the Tertiary of N. America placed by some observers in *Magnolia*, by others in *Terminalia*. *Magnolia* leaves have a thick midrib, relatively thin, flexuous *branched* secondaries with similar, not pronounced, cross-anastomoses in connection with a wide-meshed vascular reticulum. In *Terminalia* the secondaries are thick, usually unbranched, non-flexuous, with pronounced cross-anastomoses.

The Ardtun fossil is thus not *Magnolia*- but *Terminalia*-like. The hair found agrees with those figured by Solereder as ordinary Combretaceous hairs. The blackness of the fossil hair observed may be due to the tannin in the hair and an iron salt in the deposit. *Myrobalans* are articles of commerce for tanning. It and other members of the family give a black dye, with an iron salt.

Berry described several new species of *Terminalia* and placed in it various forms referred by Lesquereux, Knowlton, and others to *Magnolia*. Chaney (113) has quite recently reasserted the claims of *Magnolia* and returned to it Lesquereux's *M. hilgardiana* which is not unlike the Ardtun leaf in form and general venation, differing from it in its branching secondaries and inconspicuous cross-anastomoses. From the point of view of geographical distribution the Ardtun leaf would be more in place in the *Magnoliaceae* than in the *Combretaceae*. I propose to indicate my doubts by naming the leaf *Terminalia magnoliaefolia*. It, as stated, agrees very closely with *T. radobojensis* Ung. and comes near *T. phaeocarpoides* Berry of the Eocene of Georgia. Amongst living species *T. Chebula* is suggestive. The family occurs throughout the tropical and sub-tropical regions, including

N. Australia. *Terminalia* reached Florida. Distribution is facilitated by its fruits which float and retain their vitality for a long time.

CORNACEAE.

Cornus hebridica sp. nov.

The presence of the dogwood in the Ardtun flora is indicated by the incomplete leaf photographed (Pl. XX, fig. 3). The impression represents the basal half of a simple oval leaf $6 \times 3 \cdot 4$ cm. in extent, with 6–7 pairs of acrodrome, camptodrome curved secondaries, making an angle of 25°–30° with the midrib. They are sub-opposite below, alternating higher up, and may be as much as 1·5 cm. apart. The cross-anastomoses are well-developed, sub-horizontal, parallel to one another, and not very close together. The ultimate vascular reticulum shows polygonal meshes here and there. No tissue was obtained. It may have been such a leaf Gardner saw at Ardtun and called *Cornus hyperborea* Hr., a species founded by Heer in 1870 on fragmentary material from Greenland, Spitzbergen, etc. Chaney records *Cornus ovalis* Lesq. from the Upper Oligocene of Oregon and notes it is practically indistinguishable from *C. Studeri* Hr. of the Swiss Miocene flora. The modern representative of *C. Studeri* in the Old World is *C. sanguinea* L. (or *C. alba* L.), indigenous in Europe and West Asia and recorded from interglacial beds. In it the number of pairs of secondaries varies from 4 to 7 and, as Lesquereux observed, size of leaf and number of pairs of secondaries are not of specific value in *Cornus.*

I propose to name the Ardtun fossil *Cornus hebridica,* having affinities with the three fossils mentioned and with *C. sanguinea* L.

NYSSACEAE.

Davidoidea hebridica gen. et sp. nov.

There is a type of leaf from Ardtun, represented by several specimens in the Campbell Collection, which deserves detailed consideration. It is a large leaf, 15×10 cm., broadly ovate, with an acute apex and a bidentate edge (Pl. XXI, fig. 3). The base appears cordate, emarginate, and as if prolonged beyond the point of connection with the curved petiole. There is a well-developed sub-flexuous midrib, and

arising from it there are some eleven pairs of strong secondaries opposite and crowded in the lower part of the leaf, alternating and distant in the apical part. The lowest pair of secondaries makes an angle of 90° with the midrib, the next few higher ones angles of 55°–20°, denoting asymmetry, while the apical ones make an angle of 40°–30°. All the secondaries, except the three most apical pairs, branch and give rise on their lower (proximal) side to one or more tertiaries which, like the secondaries, end in the marginal teeth and are thus craspedodrome. The interesting feature is the fact that in the centre of the leaf the tertiaries are indistinguishable in strength and other features from the secondaries; in other words, the secondaries dichotomise, once or twice. The cross-anastomoses ("nervillae") are single or branched, arched, and the ultimate vascular reticulum is formed of fairly large polygonal meshes. No tissue of value was obtained. This leaf is reproduced in size, shape, and all its ascertainable essential features in the leaves of the genus *Davidia* Baillon, found in Tibet and West China, with several closely allied species (115). It is an anomalous genus allied to *Nyssa*, the two being separated from the *Cornaceae* as the *Nyssaceae*. The leaves of *D. Vilmoriana* Dode and *D. involucrata* Baillon vary from 7 × 5 to 14 × 10 cm. in size. I propose to call the Ardtun leaf *Davidoidea hebridica*, as, in the absence of fruits and knowledge of its epidermis, the reference to *Davidia* itself is not justified.

In the dichotomy, but not in the number and course of the secondaries, and in some other features the fossil suggests comparison with *Viburnum molle* Mx. Some of the many forms of leaf included in *Protophyllum* and *Pterospermites* from the Cretaceous and Tertiary of North America and the Arctic regions by Lesquereux, Heer and others may be ancestral forms of the *Davidia* type. *Protophyllum praestans* Lesq. of the Cretaceous of the Dakota Group of Kansas is especially suggestive.

EBENACEAE.

Diospyros brachysepala A. Br.

The ebony family appears to have made an early appearance in the Angiosperm flora as it is represented in the Cretaceous of Greenland by leaves and in beds of the same age in the

Libyan Desert by fruits. One of the 200 species of *Diospyros* extends to-day from West Africa to Australia. There are also members of the group in the extant floras of Atlantic North America and East Asia. *Diospyros* is found as late as the Pleistocene in Central Europe. Ardtun provides evidence of the presence of the genus in a leaf (Pl. XXII, fig. 1) which agrees with that of *D. brachysepala* A. Br. The Ardtun leaf is well-preserved, oblong-elliptical, 4·5 × 1·5 cm. in extent, with entire margin, tapering somewhat at base and apex. It possesses 8–9 pairs of sub-opposite or opposite curved camptodrome secondaries which make an angle of 40°–30° with the midrib. Cross-anastomoses are well-developed and the ultimate vascular reticulum of polygonal meshes is observable. Abbreviated secondaries were not observed and no tissue was obtained.

I propose to place this leaf under *Diospyros brachysepala* A. Br., a species of wide distribution in the Tertiary in Europe, North America, and Greenland. It is very like Heer's figure (116) of the variety *longifolia* (*D. lancifolia* A. Br.) and of the living species *D. Lotus* L. as represented by a specimen collected by Mr. J. Ball at Lugano. *D. Lotus* grows in S. Europe as far north as the Alps though not truly indigenous in Europe. It extends interruptedly from Asia Minor eastwards through Persia to China and Japan. *D. Lotus* is with difficulty distinguishable by its foliage from *D. Kaki* of East Asia and from *D. virginiana* of Atlantic North America.

Styraceae.

Halesioides carolinoides sp. nov.

The family *Styraceae* appears to be represented at Ardtun by the leaf illustrated (Pl. XXI, fig. 1). It is 8–9 cm. long, 3 cm. broad, oblong-lanceolate, with well-developed midrib from which 7–8 pairs of alternating curved camptodrome secondaries arise at an angle of 55°. The edge is distantly toothed. Each tooth receives a tertiary from the lower side of the secondary. Abbreviated secondaries are present uniting with the polygonal ultimate vascular reticulum and the marginal anastomoses. The cross-anastomoses are fairly conspicuous in places and sometimes irregular in their course. No tissue was obtained and the likeness to *Halesia carolina*

from the south-east of North America is based on comparison of external characters only. *Halesia* occurs at present in North America and in East Asia.

Caprifoliaceae.

Viburnum.

The grouping by Schneider (117) of the 100 or more species of *Viburnum* in seven sections largely on the leaf characters is helpful in the identification of fossil leaves.

Section I. *Opulus*.

Members of this section are recognisable by their lobed leaves. The guelder-rose, *V. Opulus*, is a well-known type. An Ardtun leaf which Gardner saw but did not collect appeared to him to be *Viburnum multinerve* Hr., recorded from the Tertiary of Greenland. This leaf was placed by Heer in the *Opulus* group. Gardner's vague statement is the only evidence known to me of the presence of the group at Ardtun.

Section V. *Lantana*.

In this group, represented by the Wayfarer's tree, *V. Lantana*, the leaves are mostly herbaceous, and mealy to the touch, owing to a felt-like covering of stellate hairs.

V. coryloides sp. nov.

There are several examples of this group in the "Campbell" Collection in Glasgow City Museum. Fig. 2 on Pl. XXII is a photographic illustration of one of these. It is an oval-oblong leaf, 8×5 cm. in extent, with a cordate base. The edge is clearly indented and crenate basally. There are 9 or 10 pairs of secondaries which arise at an angle, increasing from 30° to 90° basipetally. The basal secondaries are crowded closer together. Both secondaries and tertiaries are craspedodrome and end in the marginal teeth. The secondaries are straight, tertiaries more or less curved. In attempts to obtain tissue several tufts of stellate hairs (Pl. XX, fig. 2) were revealed. They are indistinguishable from those of the living leaf of *V. Lantana*. They help to distinguish this fossil *V. coryloides* from *Corylus* itself, the bases of the leaves of the two having many features in common.

V. Whymperi Hr.

Gardner writes of this species: "We also appear to have forms (at Ardtun) identical with those erroneously described as *Viburnum Whymperi.*" *V. Whymperi* Hr. was founded by Heer on a leaf from the Tertiary at Atanekerdluk in Greenland. He regarded it as very like *V. Lantana* L., etc. Later (118) he described a very different-looking leaf from Greenland as a variety which appears as *V. Whymperi* Hr. in the textbooks. Until some evidence of a more reliable kind is forthcoming it is better to omit *V. Whymperi* Hr. from membership of the Ardtun flora.

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EXPLANATION OF PLATES

Plate X.

Fig. 1. A portion of the sterile frond of *Onoclea hebridica* (Forbes), showing reticulate venation. A piece of the stem of *Equisetum Campbelli* Gardner, partly covered, is seen alongside. The scrap of a foliage shoot of *Sequoia Langsdorfii* (Brgt.) is indicated by pointer.
Ardtun. "Currie" Collection (C. 77). (× 1.)

Fig. 2. Sporophyll of *Onoclea hebridica* (Forbes), showing glomeruli, 1–1·5 mm. in diameter, on pinnae, 2 cm. long.
Ardtun. "Currie" Collection (C. 4). (× 1.)

Fig. 3. A portion of same (5/2). (See text-fig. 1 for key.)
Photographs of figs. 1–3 by Dr. T. M. Finlay.

Fig. 4. Leaf of *Ginkgo adiantoides* Ung. (× 1.)
Site near Loch Garda, Isle of Skye. Collected by G. V. Wilson. (See also Pl. XVIII, fig. 3.)

Fig. 5. Seed of same, revealed by splitting slab. (× ½.)
Ardtun. "Gardner" Collection, Royal Scottish Museum, Edinburgh.

Plate XI.

Fig. 1. *Araucaria Heddlei.* (× 1.)
Collected by Professor Heddle, Isle of Canna. "Currie" Collection, Geol. Institute, University of Edinburgh (C. 62). Counterpart in the Royal Scottish Museum, Edinburgh.

Fig. 2. *Cryptomeria Gardneri.* (× 1.)
Isle of Canna. Collected by Professor Heddle. "Currie" Collection, Geol. Institute of University of Edinburgh (C. 63). Slab was broken in two; one half is in the Royal Scottish Museum.

Fig. 3. Photograph of *Glyptostrobus europaeus* foliage. (× 1.)
Koch's specimen (838) from Ardtun. Hunterian Museum, University of Glasgow.

Plate XII.

Fig. 1. Photograph of leaf of *Smilacites grandifolia* Ung. (× 1.)
Ardtun. Royal Scottish Museum, Edinburgh.

Fig. 2. Central portion of leaf of fig. 1 enlarged. (× 3.)

Fig. 3. A little of same leaf further enlarged, showing quadriform meshes, and suggestion of overlying stalked berry-like body, indicated in fig. 2.

Fig. 4. Another leaf referred to *S. grandifolia* Ung., showing leaf-tip and venation. (× 1.)
Ardtun. Hunterian Museum, University of Glasgow (No. 508).

Fig. 5. Leaf of *Pistia Inglisi*. (× 1.)
Collected by Mr. A. I. Inglis, from Portree, Isle of Skye. Royal Scottish Museum, Edinburgh.

Plate XIII.

Fig. 1. *Betula cuspidens* Sap.
"Campbell" Collection, Glasgow City Museum. (× 1.)
Fig. 2. *Betula cuspidens* Sap. (× 1.) Upper half of leaf.
"Currie" Collection (C. 25).
Fig. 3. Biserrate edge of leaf of *C. MacQuarrii*. (× 4.)
Figs. 1 and 3 are from photographs taken by Dr. R. Gregory Absalom of Ardtun. Specimens in the Glasgow City Museum.
Fig. 4. *Castanea dentoides*.
Ardtun. "Currie" Collection (C. 67), Geol. Institute, University of Edinburgh.
Fig. 5. *Salix Finlayi*. (× 1.)
Ardtun. "Currie" Collection (C. 49*b*), Geol. Institute, University of Edinburgh.

Plate XIV.

Fig. 1. Leaf of *Corylus MacQuarrii* (Forbes). (× $\frac{4}{5}$), showing venation and overlapping lobes of cordate emarginate base.
Ardtun. "Koch" Collection (817).

Plate XV.

Fig. 1. Transverse section of wood of *Cupressinoxylon* (M'Culloch's Tree), Isle of Mull.
Photographed by Dr. D. Russell. (× 240.)
Fig. 2. Leaf of *Podocarpus eocenica* Ung. (× 1.)
Ardtun. "Currie" Collection (C. 26), Geol. Institute, University of Edinburgh.
Fig. 3. *Magnolia Inglefieldi* Hr. (× 1.)
Lake Fada (near), Isle of Skye. Collected by Mr. G. V. Wilson. V. 4045*b* of Geological Survey Collections (Scotland). By permission of the Director.

Plate XVI.

Fig. 1. Photograph of leaf of *Protophyllum Barclayi*. (× 1.)
Ardtun. Hunterian Museum, University of Glasgow. (511). Collected by Dr. T. Barclay.
Fig. 2. A portion of same enlarged (× 10.), to show ultimate quadriform reticulum.

Plate XVII.

Fig. 1. Edge of leaf of *Cercidiphyllum japonicum*, showing gummy exudation, photographed alongside crenate edge of *Cercidiphyllum* (*Grewia*) *crenatum*. (× 7.)
C. japonicum leaf was given from the herbarium of the Royal Botanic Garden, Edinburgh. *C. crenatum* edge was provided by a "cellulose" impress of Ardtun fossil leaf in Royal Scottish Museum, Edinburgh.

Fig. 2. Leaf of *Cercidiphyllum crenatum* (Br. in lit.). Showing "pitted" glandular crenate edge. (×).
Ardtun. "Campbell" Collection, Glasgow City Museum. Photographed by Dr. R. G. Absalom.

PLATE XVIII.

Fig. 1. Leaf of *Berchemia Wilsoni.* (× 1.)
Site near Loch Fada, Isle of Skye. Collected by G. V. Wilson.
Fig. 2. *Platanus Kochi.* (× 1.) Ardtun.
Fig. 3. Photograph of slab from Ardtun in the "Campbell" Collection, Glasgow City Museum. Photograph (1/1) of leaf and fruit of *Ilex ardtunensis*, n. sp. at *c*. *Betula cuspidens*, Sap. (*b*). Left of *b* is leaf of *Ginkgo adiantoides.*

PLATE XIX.

Fig. 1. Photograph of leaf of *Rhamnus lancaeformis.* (× 1).
Of Ardtun. Geol. Dept., University of Aberdeen.
Fig. 2. Photograph of leaf of *Rhamnus multinervatus* (Forbes). (× 1.)
Of Ardtun. Bot. Dept., University of Aberdeen.
Fig. 3. *R. multinervatus.* (× 1.) Showing acuminate apex and opposite secondaries.
Fig. 4. Leaf of *Rhamnus major* (Forbes). (× 1.)
Ardtun. Koch Collection, (818), Hunterian Museum, University of Glasgow.
Fig. 5. Leaf of *Amelanchier ovalis.* (× 1.)
Ardtun. "Koch" Collection (831*b*), Hunterian Museum, University of Glasgow.

PLATE XX.

Fig. 1. *Zizyphoides ardtunensis.* (× 1.)
Ardtun. Geol. Dept., University of Aberdeen.
Fig. 2. Stellate spicate hair-tuft obtained from leaf of *Viburnum coryloides.* (× 240.)
Photographed by Dr. T. M. Finlay.
Fig. 3. Leaf of *Cornus hebridica.* (× 1.)
Ardtun. "Koch" Collection (831*a*), Hunterian Museum, University of Glasgow.
Fig. 4. Photograph of leaf of *Hamamelis suborbiculata.* (× $\frac{2}{3}$.)
From Ardtun, Isle of Mull (2/3). Collected by Professor J. Geikie. Photographed by Dr. T. M. Finlay. Geol. Institute, University of Edinburgh.

PLATE XXI.

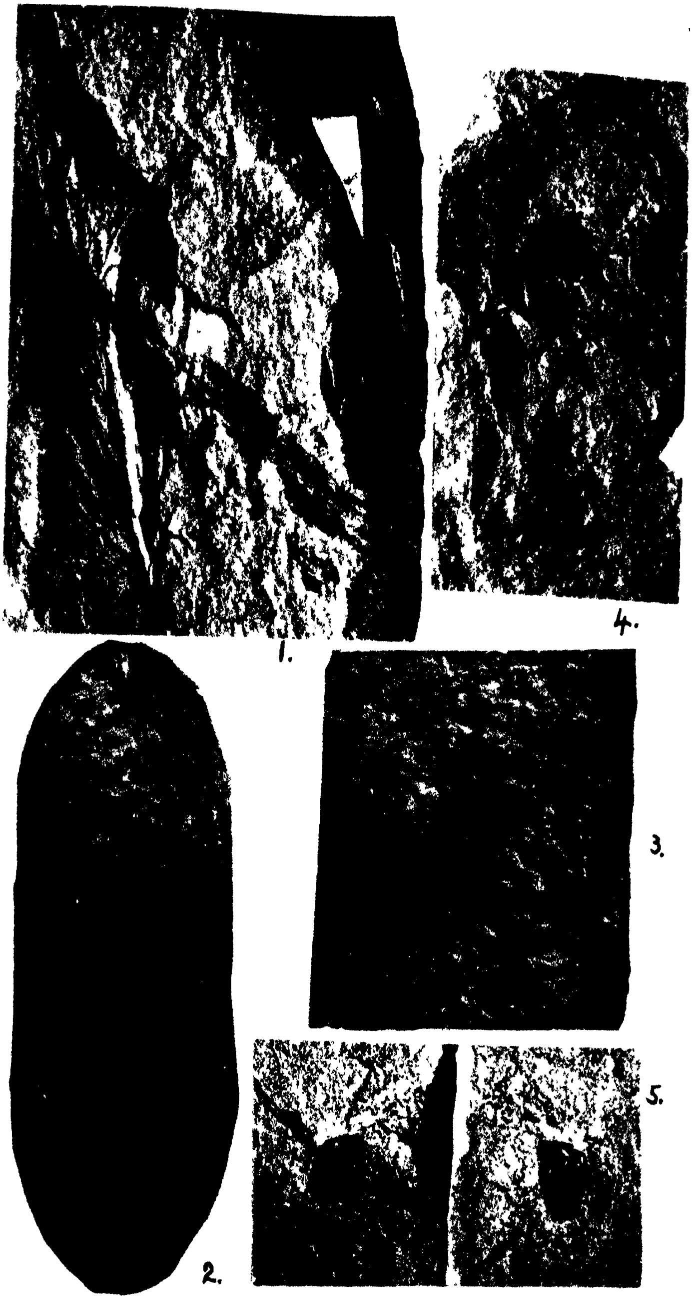
Fig. 1. *Halesioides carolinoides.* (× 1.)
Ardtun. Hunterian Museum (504 L), University of Glasgow.
Fig. 2. Leaf of *Terminalia magnoliaefolia.* (× $\frac{2}{3}$.)
From Ardtun, Isle of Mull. Specimen in Geological Division, Glasgow City Museum. Given by Lord Archibald Campbell. Photographed by Dr. R. G. Absalom.

Fig. 3. Leaf of *Davidoidea hebridica*. ($\times \frac{2}{3}$.)
Ardtun, Isle of Mull. Photograph of specimen in "Campbell" Collection of Glasgow City Museum, by Dr. R. G. Absalom.

Plate XXII.

Fig. 1. Photograph of leaf of *Diospyros brachysepala* A. Br. ($\times$ 1.)
Ardtun, Isle of Mull. Royal Scottish Museum, Edinburgh.

Figs. 2, 3. Leaves of *Viburnum coryloides*. ($\times$ 1.)
Ardtun. "Campbell" Collection, Glasgow City Museum. Photographed by Dr. R. G. Absalom.



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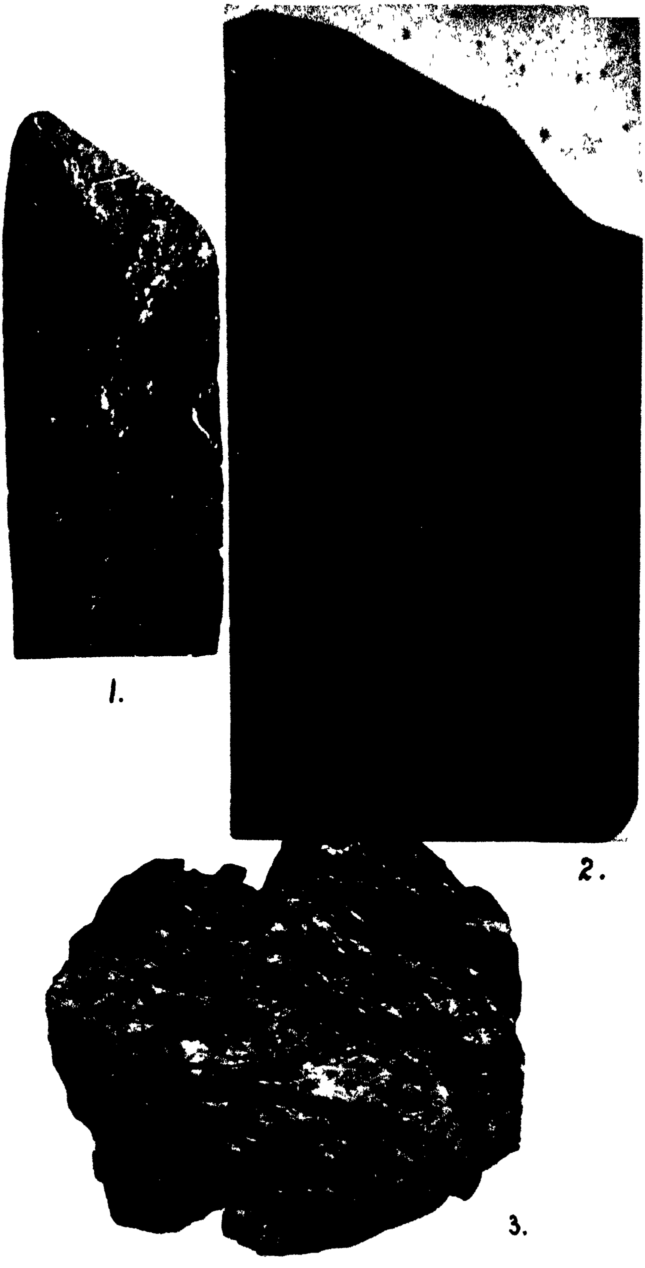

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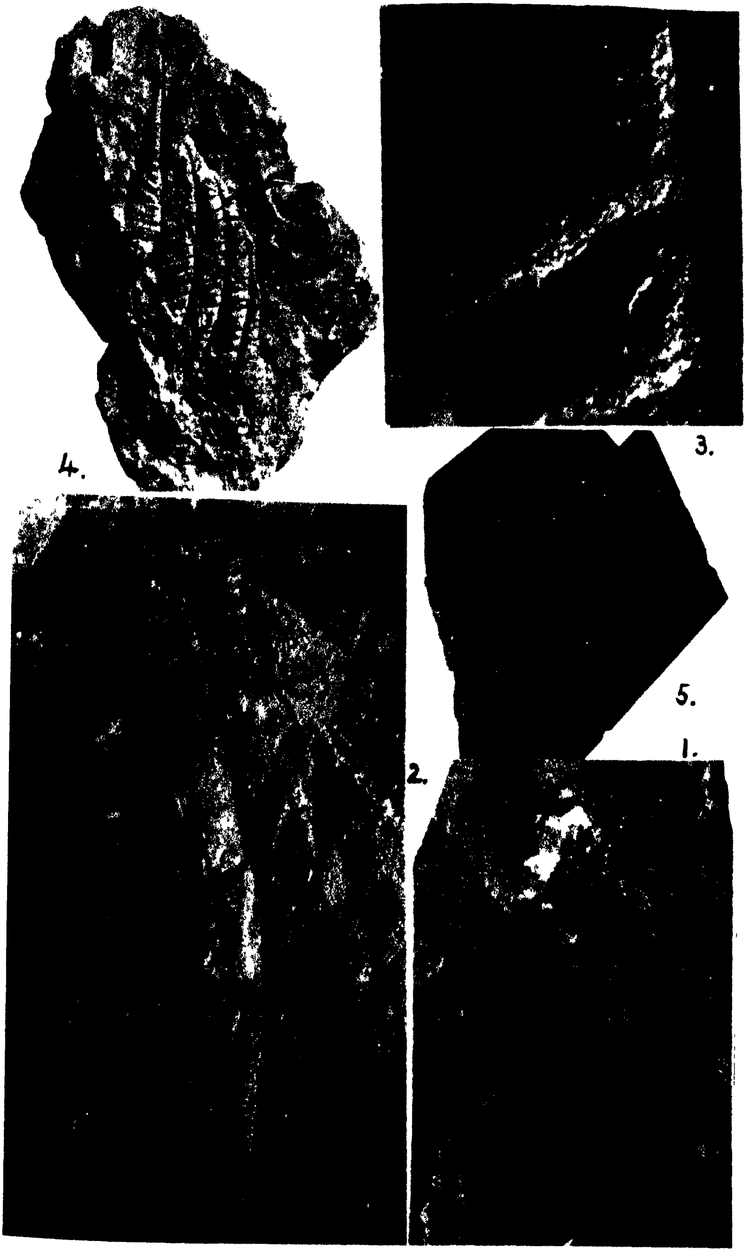

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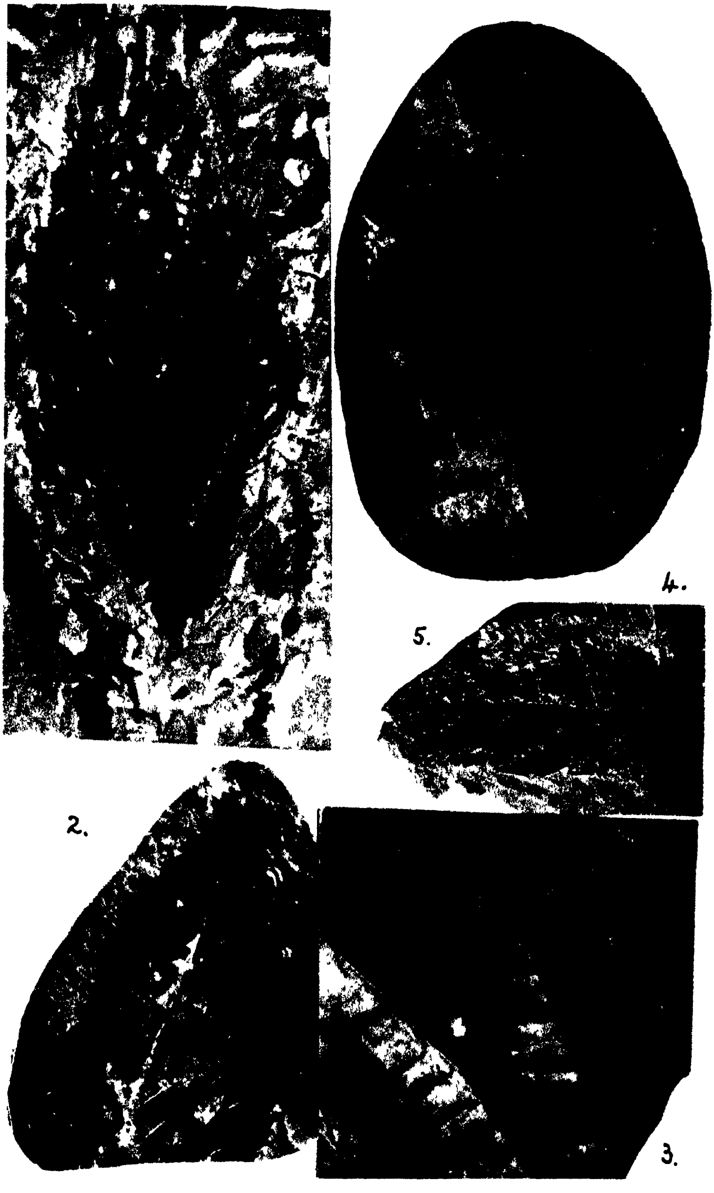

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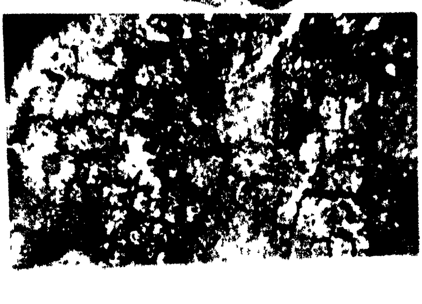

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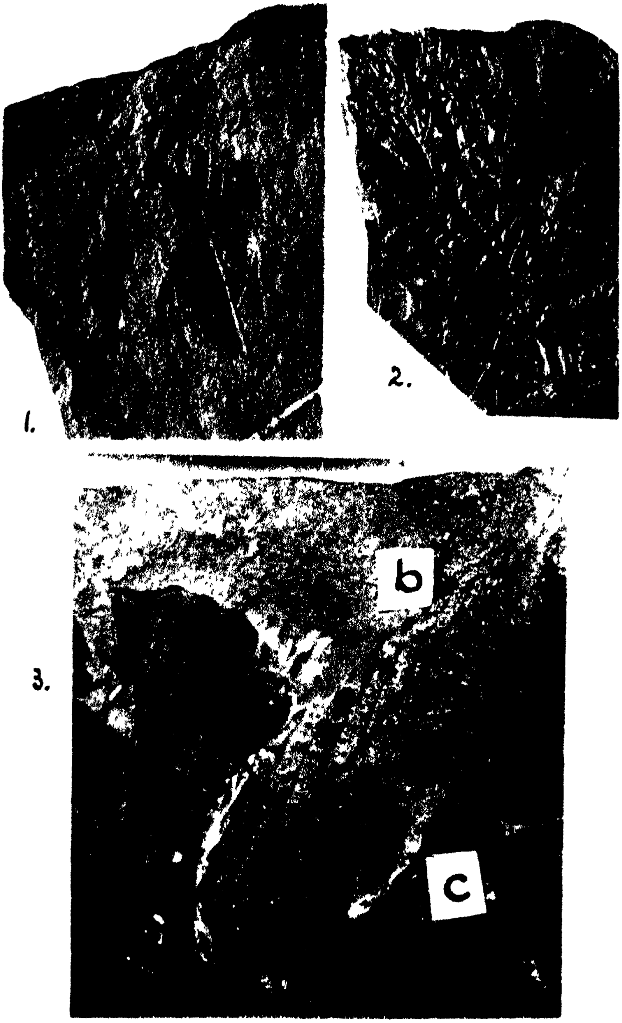

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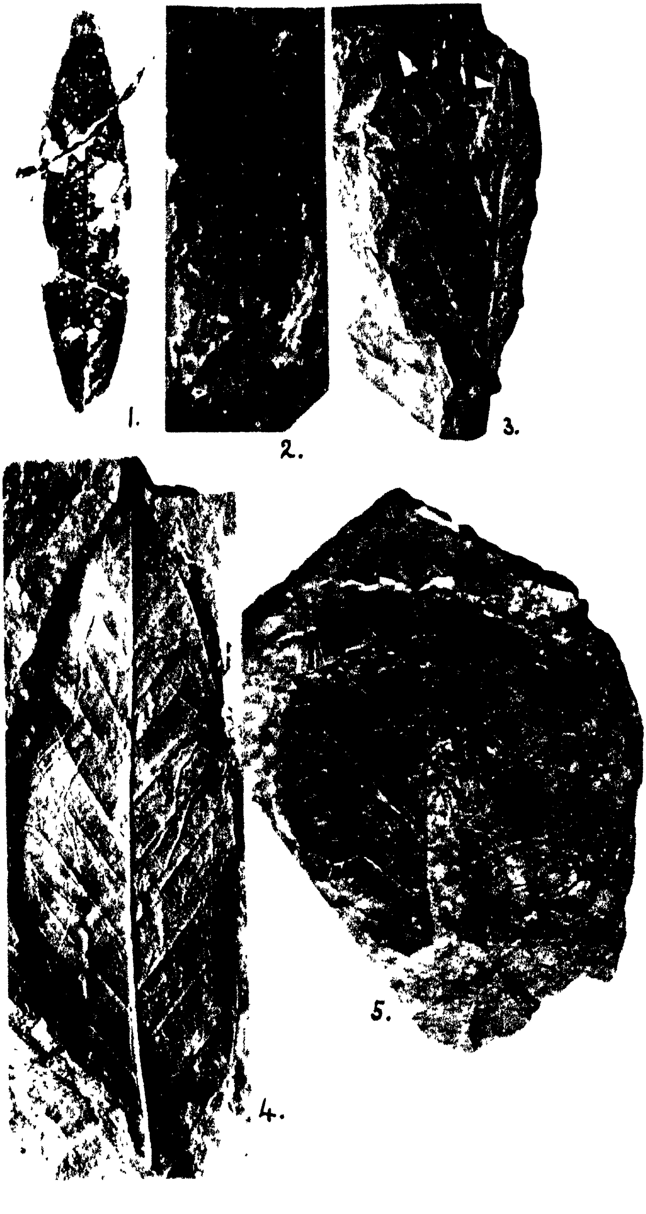

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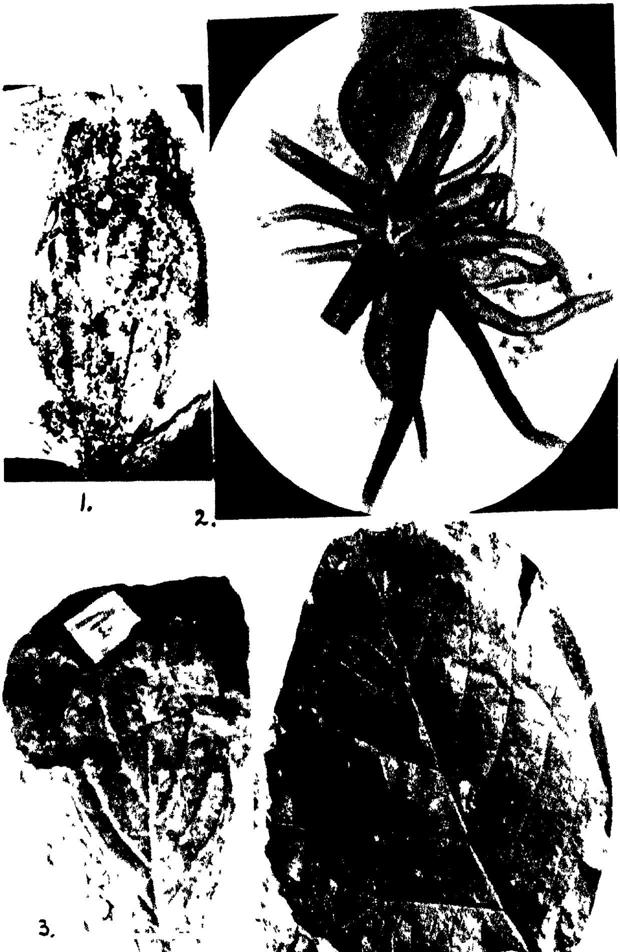

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Phomopsis scobina (Cke.) v. Höhn. and Phomopsis controversa (Sacc.) Trav. on Ash. By J. A. Macdonald, Ph.D., and J. R. Russell, B.Sc. (With Pls. XXIII, XXIV.)

(Read 17th June 1937.)

Introduction.

Pycnidial fungi are fairly common on the ash (*Fraxinus excelsior*) in Scotland. In large part they occur as saprophytes on dead twigs, fruits and leaves; but in certain cases there is no doubt that they are growing parasitically on living tissues. Two such pycnidial fungi were found associated with twigs that had died back or with cankered and girdled stems at Castle Douglas (Kirkcudbrightshire), Chirnside (Berwickshire), Glen Tress (Peeblesshire), Moredun (Midlothian), St. Andrews (Fife), Trochry (Perthshire), and Inverness. They were assigned to *Phomopsis scobina* (Cke.) v. Höhn. and *Phomopsis controversa* (Sacc.) Trav., species which, in the past, have been separated from one another largely on account of differences in spore type. There is a body of opinion which holds the view that these two types are forms of the same species and that the differences in size are inconstant, the larger spored form grading easily into the smaller. The very generally accepted view is too, that the species of *Phomopsis* occurring on ash are the imperfect stages of members of the genus *Diaporthe*, with which, it is stated, they usually occur associated in nature. With this latter point the present paper does not deal, but it brings forward evidence to show that *Ph. scobina* and *Ph. controversa* differ from each other so markedly both in pathogenicity towards ash and in cultural characters that there seems to be no doubt that they should be regarded as separate species.

The fungus now referred to as *Phomopsis scobina* was originally described as *Phoma scobina* by Cooke (1885). Later Von Höhnel (1903) transferred it to a new genus *Myxolibertella* as, in addition to the ordinary 'a' spores, it possessed

the elongated, filiform, hooked 'b' spores which he made diagnostic for this genus. Three years afterwards von Höhnel (1906) placed the species in the genus *Phomopsis* and Grove (1935) has listed 65 *Phomopsis* species which possess 'b' spores of similar type. Where the 'b' spores were found alone this led to the use of yet another generic name—*Phlyctaena* [Ellis (1913)]. *Phomopsis controversa* was also first described as a species of *Phoma* by Saccardo in (1884) and transferred to the genus *Phomopsis* by Traverso (1906). It is said to differ from *Ph. scobina* in having shorter 'a' spores and in the absence of 'b' spores. Grove (1935 *a*) is inclined to discredit the value of this difference in spore size, and states, after his description of the species, "*Phomopsis scobina* Cooke and *P. pterophila* Died. are almost certainly the same species as this."

Both the above imperfect stages are accepted as being connected with the species of *Diaporthe* of the same specific names, i.e. *D. scobina* and *D. controversa*. Wehmeyer (1933) in his account of "The British Species of the genus *Diaporthe*" includes both *D. scobina* and *D. controversa* in "the largest species-complex of the genus," *D. eres*, listing them provisionally under the same host "form." He gives *Ph. scobina* and *Ph. controversa* among the conidial connections of this form, drawing attention to the confusion caused by the overlap in the spore measurements given by different authors.

The Fungi in Pure Culture.

Spore Size and Type.—Pycnidia of *Ph. scobina* may contain either 'a' or 'b' spores. The 'a' spores, when squeezed out of a pycnidium, may remain attached terminally to the sporophores on which they are produced. With regard to the size of the two types of spores, Cooke (1885) stated that the 'a' spores were 10–12 × 3–3·5 μ. Von Höhnel (1903) described the 'a' spores of his *Myxolibertella* as 8–12 × 1·5 μ and the 'b' spores as 20–25 × 1 μ. Grove (1917) originally gave measurements of 10–12 × 1·5 μ and about 20 × 1 μ respectively; but in his "British Stem and Leaf Fungi" (1935 *b*) he expresses doubt as to the accuracy of Cooke's figures, and supplies measurements of 7–10 × 2–2·5 μ for the 'a' spores and 20–25 × 1 μ for the 'b' spores. His measure-

ments for the respective sporophores are 10–12 × 1·5 μ and up to 5 μ. Ellis (1913) gave the size of the sporophores bearing the 'a' spores as up to 18 × 1 μ.

The writers examined spores from pycnidia formed in nature and in pure culture. The origin of the pycnidium did not appear to affect the size of the spores. All measurements were made on naturally extruded spores freshly mounted in a glycerine-alcohol and potassium acetate mountant which did not seem to alter the size of the spores immediately. This precaution is necessary, as the 'a' spores at any rate increase considerably in length before germination actually takes place. The 'a' spores were found to vary from 7–13 × 2–4 μ with an average of 10·5 × 3 μ approximately, while the 'b' spores were 16·5 – 25 (average 20·5) × 1 μ. Both types are hyaline (fig. 1). Pycnidia of *Ph. controversa* frequently are clearly marked off from their surroundings by dark zone lines. In addition they contain only 'a' spores, and these are smaller, on the average, than the corresponding spores of *Ph. scobina*. Saccardo (1884) gave the spore size as 7–8 × 2–2·25 μ and that of the sporophores as 12 × 1 μ. Grove (1935 *a*) gives 7–8 × 2–3 μ and 20 × 1·5 μ respectively. Using the same method as with *Ph. scobina* the writers obtained figures of 5·5–9 × 1·5–4 μ, with an average of 7 × 2·5 μ approximately. These spores are hyaline also (fig. 2). In spite of the overlap in the sizes of the 'a' spores of the two types there is never any doubt as to which is present if the contents of a single pycnidium are examined under the microscope.

Agar Cultures.—Either 'a' or 'b' type spores of *Ph. scobina*, when cultured on nutrient agars, give rise to a fairly slow-growing, tufty mycelium, which is raised on the surface of the agar in solid masses. The 3-inch surface of an agar slant is only half-covered at the end of three weeks. The mycelium is white to begin with. After six to eight weeks little green-grey masses form. These are the pycnidia which produce shining pink dots, of semi-liquid consistency, composed of spores. Older cultures often develop a distinctly pink tinge over the general mycelium. There are no black zone lines produced. Spores of *Ph. controversa* sown on similar agar slopes produce a rapidly growing, superficial mycelium which is also white in colour, but has a diffuse, woolly appearance.

The surface of a 3-inch slope is covered by this mycelium in two to three weeks. Pycnidia form more quickly and spores are produced within a month. In this case they are usually extruded in yellowish tendrils often fully half an inch in length. Dark zone lines are frequent, particularly in fertile cultures. The superficial mycelium may develop a brownish colour as it grows older.

Infection of Plums and Apples.—Mycelium of *Ph. scobina* inoculated into fresh, undamaged plum fruit gave little sign of growth at the end of three weeks, except on the treated cut. Ultimately a rot was produced. It spread very slowly. Twelve to fifteen weeks were required before all the tissues of the fruit were attacked. The rot caused a sagging and wrinkling of the surface and was relatively dry (fig. 12). Pycnidia were numerous. They appeared at the end of nine weeks and produced small shining masses of spores from ten weeks onwards. In the case of *Ph. controversa* a fairly rapid rot was produced and was accompanied by a copious exudation of juice. Within four weeks the fruit was completely attacked. In some cases finger-like processes grew out from the cut surface of the plum after three weeks. Some of these attained a length up to 1 inch (fig. 11). They all remained sterile, and were accompanied, and subsequently overgrown, by the ordinary superficial mycelium.

The effects of both fungi on apple fruit were similar to those described for plum, but were produced very much more slowly. *Ph. controversa* rotted the fruit in five months, while *Ph. scobina* required much longer.

Oxidation of Tannic Acid.—Both fungi were grown in Petri dishes on beef-extract agar made up with the addition of varying amounts of tannic acid, according to Bavendamm's method (1928). The strengths of acid employed were ·5, ·25, ·1 and ·05 per cent. It was found that both mycelia were capable of producing obvious oxidation rings with the ·5 per cent. strength, but that the ring produced by *Ph. scobina* was considerably darker. With ·25 per cent. the *Ph. scobina* ring was as dark as that produced with ·5 per cent. by *Ph. controversa* and the *Ph. controversa* ring was very faint. The latter did not produce a ring with either ·1 or ·05 per cent., while with *Ph. scobina* there were still definite signs of oxida-

tion. Applying Bavendamm's interpretation of similar results one would expect to find a considerably greater tendency to attack lignified tissues in the case of *Ph. scobina* than in that of *Ph. controversa.*

Growth on Sterilised Ash Twigs.—Both fungi were inoculated into T-shaped cuts made in the bark of ash twigs sterilised in boiling tubes. The mycelium of *Ph. scobina* gave rise to the characteristic solid growth on the surface of the cut. There was no rapid spread on the outside of the twig. The mycelium penetrated the tissues, and, after twenty-one days, began to burst out through the bark at irregular intervals and also appeared growing from the cut end of the twig (fig. 13, *b*). In the case of *Ph. controversa* the typical superficial mycelium was produced and covered the surface of the twig in twenty-one days. There was no marked penetration of the internal tissues by hyphal masses during this period (fig. 13, *a*).

This result bears out the suggestion that *Ph. scobina* has a more marked tendency to attack both wood and bark than has *Ph. controversa.*

The Effect of the Fungi on Ash.

Both fungi occur associated with ash twigs which are dead or dying back from the tips. Sometimes one only appears to be present; but they do occur together or associated with other pycnidial forms. Usually pycnidia are produced freely. The only method of determining rapidly which fungus is present is to examine the contained spores. Pycnidia must be selected at random, and, as only a relatively small number can be investigated, it is not possible to be certain that there are not some present formed by fungi other than those under investigation. However, the following observations are based on cases in which one fungus only appeared to be present and are supported by evidence obtained from infection experiments.

A number of methods of obtaining infection was employed with both *Ph. scobina* and *Ph. controversa.* Suspensions of spores were made in water and in 2 per cent. malt extract solution. These were injected under the bark and into the terminal buds by means of a hypodermic syringe, or spread

on the wounded surface of the bark. None of the methods was particularly successful, and by far the best results were obtained when T-shaped cuts were made in the young bark of the twigs and pieces of mycelium from a pure culture of the appropriate fungus were inserted. The inoculated wounds were then bound round with damp cotton-wool and covered with electricians' adhesive tape. After three weeks the coverings were removed and the percentage of positive infections obtained was ascertained. Using twigs of three, two or one years of age, 72 per cent. of the inoculations with *Ph. scobina* proved successful (36 out of 50), while with *Ph. controversa* 48 per cent. were positive (43 out of 90) (fig. 14).

In growing on young twigs of ash *Ph. scobina* sometimes produces a mild witch's broom effect (fig. 17). This seems to be caused by the destruction of the terminal bud of a leading shoot. The lateral buds take over its activity and the terminal buds of the twigs thus formed may be killed in their turn. Thus the whole process is repeated a number of times, giving a group of small branches.

When the fungus kills back an entire twig and spreads into a larger branch an infection of unlimited size may be produced (fig. 16). Some of these infections have been observed measuring 25 cm. in length and completely encircling branches up to 2·7 cm. in diameter. Very often there are several infections close together and the spread of any individual is limited by making contact with the next. In any event it is almost always possible to detect in the centre of an infection the remains of the twig which mark the point of entry of the fungus. Typical infections show a brown, discoloured, sunken bark which has the appearance of being saturated with water. Pycnidia are freely formed as time goes on. In old infections the bark cracks and drops away round the stump of the central twig and a definitely cankered appearance is produced (fig. 15). Masses of callus tissue are discernible on the central canker and here and there over the wider depressed area. They are raised quite distinctly above the general level of the surface of the bark. They represent continuous though ineffective barriers to the advance of the fungus. *Ph. scobina* may be found associated with small cankers which, judging by the complete, raised, callus border round the

infected part, might appear to have been isolated successfully from the healthy stem tissues. This is thought to be unlikely owing to the form of the unlimited cankers just described and for reasons which will be advanced later.

The rate of spread of the fungus was determined by inoculation experiments. It was found to vary considerably. The maximum spread obtained in four months was 1·5 cm. beyond the cut surface longitudinally in either direction and round a twig 3 cm. in circumference transversely. Browning of the woody tissues was observed macroscopically for distances up to 4 cm. from the wound in either direction longitudinally.

Sections of infected stems cut at different stages provide an interesting series. After three weeks the actual area inoculated shows browning of all tissues outside the wood, sometimes for as much as two-thirds of the stem circumference (fig. 5). There is no sign of healing taking place. This browning of the tissues has been found a useful guide to the extent of any infection, as it is undoubtedly associated with the spread of the hyphae and, in the softer tissues at any rate, is found to keep pace with them. The brown material gives positive results with the usual tests for tannin, *e.g.* it turns blue-black with ferrous sulphate. The browning of the bark tissues is discernible for some little distance either below or above the point of inoculation. There is also some browning of the wood, though only at the wound. In longitudinal sections hyphae were detected in the outer medullary ray cells, and even in the lignified elements in a few cases. Sections cut after two months may show a complete cork cambium running from the most superficial tissues into the wood cambium and cutting off cork towards the infected bark tissues. Seen in longitudinal section the general direction followed by this cambium is oblique, so that the region cut off by it is spindle-shaped. Thus the tangential spread of the fungus in the bark is checked, corresponding with the limited canker stage described above. Sometimes, however, the cork layer is incomplete in the region of the fibres (fig. 6). In either case browning of the wood is clearly marked and hyphae have penetrated almost an entire annual ring. In general, they are not readily observed, but they are easily picked out in parts of the medullary rays. After four months sections show that the fungus has been able to spread laterally

in the wood to a sufficient extent to overcome the check offered by the cork barrier in the bark. The activity of the wood cambium has begun to be affected near the wound but opposite the healthy bark. The amount of wood which this cambium is producing is reduced (fig. 7). It no longer stains bright red with safranin, indicating a reduced degree of lignification. This change is obvious both above and below the wounded region. Naturally formed cankers of unknown age show these features particularly well. It is possible to trace the increase in wood production from the very small amount being formed by the cambium at the sides of the canker to the "normal" amount seen at some distance from the wound. The browning symptom is well marked in the wood. While all the wood from cambium to pith may be browned at or near the point of infection, it is usual for the inner ring or rings to exhibit browning first to the sides of this area (fig. 8). Hyphae are numerous in the medullary rays, and spread out from them into adjacent parenchyma cells and woody elements. This indicates that the principal path for the rapid spread of the hyphae is radially by means of the ray cells. Hyphae are also found in the outer part of the pith, thus making it clear that the fungus may pass inwards by one ray, cross a number of pith cells and pass outwards again by means of another ray. This would account satisfactorily for the general infection of the inner parts of the wood while portions farther out are not yet visibly infected. Ultimately the new wood at the side of the wound becomes infected from within, and fine young hyphae can be detected in this region.

The fungus attack leads to the breakdown of the starchy contents of the infected cells; but the hyaline hyphae do not appear to damage the general wall structure to any marked degree, though they are both inter- and intra-cellular, passing through the walls by means of boreholes.

Ph. controversa also occurs fairly freely on dead or dying back ash twigs. It is most common on poorly developed shoots, *e.g.* those arising towards the base of old trunks and making weak growth due to shading. When the die back with which it is associated reaches a larger stem, the fungus, apparently, is restricted fairly quickly in its tangential spread. This is brought about by the activity of a cork cambium

isolating the infected part and giving a limited canker similar in appearance to that produced by *Ph. scobina.* In this case, however, the exclusion seems to be complete and the attacked region remains isolated.

The result of artificial inoculations indicates that the rate of spread of *Ph. controversa* is much slower than that of *Ph. scobina.* The maximum spread obtained, before healing took place, at no time exceeded 5 mm. in any direction.

Sections cut three weeks after infection showed a less extensive browning of the bark tissues than with *Ph. scobina.* The discoloration did not spread more than one-third of the way round the stem at the point of inoculation. There was again some browning of the wood, mostly near its outer limit; but hyphae appeared to be restricted to the tissues outside the wood. The wood cambium was already giving rise to a layer of cork on its outer surface (fig. 4). This wound tissue was continued as far as the fibres by the activity of a cork cambium. Sections cut above or below the wound surface showed the cork barrier already completed. The fungus mycelium did not, as a rule, penetrate to the wood cambium. After two months the barrier at the wound may also be complete, and at the end of four months it always is (fig. 3). The browning of the wood is still visible in the outermost annual ring, but it has not spread.

A comparison is useful between the effects produced by the two fungi and those following on the making of control cuts. In the latter case, after three weeks the layer of cork tissue healing the wound is practically complete. If, as sometimes happens, the knife cut has entered the wood, the wood cambium ring has already reformed. After two months there is a many-layered cork tissue isolating the wounded area, while the cut in the woody tissues has been filled in by the production of cork cells apparently from the internal surface of the newly formed cambium (fig. 10). Browning of the wood and bark tissues in the immediate vicinity of the wound has taken place. As with *Ph. controversa,* there was very little radial or tangential spread of the discoloration either transversely or longitudinally. Speaking generally, the production of tannin was least in the controls, slightly greater in *Ph. controversa* infections and very much greater in those caused by *Ph. scobina.*

Discussion.

The writers feel that the evidence brought forward is sufficient to justify the retention of the specific names *Phomopsis scobina* and *Phomopsis controversa* to designate and separate the two fungi investigated. This view is founded, firstly, on the general culture differences which have been maintained continuously over the period of three to four years during which the fungi have been in culture, and secondly, on their marked difference in pathogenicity towards the host plant *Fraxinus excelsior.* As is to be expected, this latter fact seems to be linked with the more rapid growth rate of the former fungus in the living host tissues in general and with its greater ability to attack woody tissues in particular. It seems that this, in its turn, must be connected with differences in the amount of particular enzymes present in the hyphae. This is suggested by the greater avidity with which *Ph. scobina* oxidises tannic acid, thereby indicating the presence of a higher concentration of the enzyme tannase in its mycelium. It may be that further investigation would show that enzymes present in the one were absent altogether from the other. Complementary to the weaker parasitism of *Ph. controversa* is its greater adaptability to a saprophytic existence.

Summary.

1. *Phomopsis scobina* and *Ph. controversa* were isolated from living and dead twigs and branches of *Fraxinus excelsior* from a number of districts in Scotland.

2. Both grew readily in culture, forming mycelia which differed from each other consistently. Pycnidia were freely produced. In the case of *Ph. scobina* these contained either smaller 'a' spores or larger curved 'b' spores, which were extruded in shining, pink drops. The 'a' spores of *Ph. controversa* were smaller on the average than the corresponding spores of the former, and were usually set free from the pycnidia in yellow tendrils. 'b' spores were absent.

3. Artificial infection experiments confirmed a marked difference in the degree of pathogenicity of the two fungi towards ash. *Ph. scobina* may kill back twigs and form cankers of unlimited size on larger stems, owing to its more

rapid growth rate and more pronounced power of penetrating woody tissues. *Ph. controversa* may also cause a die-back of small twigs; but the cankers subsequently formed on larger stems are strictly limited, as the fungus mycelium is easily cut off by the activity of cork cambia owing to its slower growth rate and inability to attack living wood.

This work was begun by J. R. Russell under the supervision of Dr. Malcolm Wilson in Edinburgh, and, some time after he left to take up an appointment in India, was completed by J. A. Macdonald in the Botany Department of the University of St. Andrews. Acknowledgment is gratefully made of the supervision received and the facilities placed at the disposal of the writers.

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DESCRIPTION OF PLATES.

Fig. 1. *Phomopsis scobina*, 'a' spores (*a*), and 'b' spores (*b*). × 250.

Fig. 2. *Ph. controversa* spores. × 250.

Fig. 3. *Ph. controversa*, 4 months old artificial infection. × 11.

Fig. 4. *Ph. controversa*, 3 weeks old artificial infection. Healing from wood cambium at (*a*). × 11.

Fig. 5. *Ph. scobina*, 3 weeks old artificial infection. × 11.

Fig. 6. *Ph. scobina*, 2 months old artificial infection, showing part of oblique cork layer running from wood cambium to fibres. × 11.

Fig. 7. *Ph. scobina*, 4 months old artificial infection. The amount of new wood produced is reduced to the left of the wound. × 11.

Fig. 8. *Ph. scobina*, natural infection. Section of wood to left of the original infection. The medullary rays and large vessels of the inner annual ring show browning. This is absent from the corresponding elements of the outer ring towards the left of the section. × 11.

Fig. 9. *Ph. controversa*, natural infection. Section cut above point of entry to show fungus isolated in cortex. × 11.

Fig. 10. Control twig 2 months after cutting the wound. × 11.

Fig. 11. Plum with *Ph. controversa* 3 weeks after infection. Finger-like processes on the left. × ½.

Fig. 12. Plum with *Ph. scobina* 2 months after infection. × ½.

Fig. 13. *Ph. controversa* (*a*) and *Ph. scobina* (*b*) on sterilised ash twigs. × ½.

Fig. 14. Twig inoculated with *Ph. scobina*. × 1.

Fig. 15. *Ph. scobina*, natural canker showing cracking. × 1.

Fig. 16. *Ph. scobina*, natural canker showing twig base which marks point of infection. There are numerous pycnidia on the depressed bark. × 1.

Fig. 17. Witch's broom caused by *Ph. scobina*. × ⅕.

J. A Macdonald and J. R Russell.

J. A. Macdonald and J. R. Russell

Anatomical Investigations on *Ligusticum scoticum*.

By Murray Lunan, B.Sc. (With Pl. XXV.)

(Read 17th June 1937.)

During the last week of July 1936 material for the anatomical study of *Ligusticum scoticum* was collected from the seashore five miles east of St. Andrews.

The plant consists of a short, erect, perennial rhizome covered with persistent leaf-bases, and giving rise to annual leaves and inflorescence-shoots reaching a height of 25 to 40 cm. and to roots penetrating into the sand and gravel to a depth of about a metre.

The Seedling.

Seeds were planted on 6th October. In a warm cupboard and in a warm frame germination failed to take place, but in a cold frame an 80 per cent. germination was observed during the latter half of January. During the first four weeks of germination the hypocotyl was strongly curved, and the linear cotyledons were still enclosed in the testa which had been drawn to the surface of the soil by the epigeal development of the seedling.

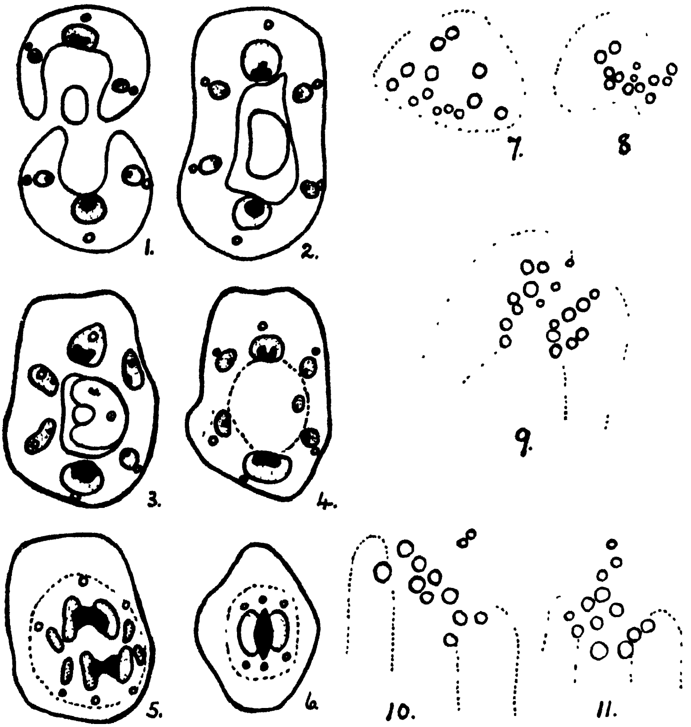
By 25th February the hypocotyl had straightened by hyponastic growth, and this made practicable the cutting of serial sections. At this time the cotyledons are spathulate, and their bases fuse together to form a sheath round the epicotyl. Each cotyledonary stalk shows a well-developed median bundle and two lateral bundles, all of collateral type. In the median bundle, phloem surrounds the xylem except at the adaxial protoxylem; in the lateral bundles the xylem is poorly developed. Towards the abaxial side of each bundle, and occasionally towards the abaxial side, there is a well-developed secretory duct. These ducts are formed at a very early stage, even before the lignification of the xylem.

The hypocotyl averages 0·9 cm. in length, is of greater diameter than the root, and is further distinguished by its

glabrous surface and slight anthocyanin pigmentation. In the hypocotyl the bundles passing down from the cotyledonary stalks rapidly converge towards the centre of the axis and ultimately fuse together in the manner indicated by the drawings on figs. 1–6. At the point where the cotyledonary sheath has fused with the axis, the phloem of each median bundle has divided into two branches which swing laterally on either side of the xylem (fig. 5). On each side of the cotyledonary plane the phloem branch of the median bundle and the phloem of the lateral bundle of one cotyledon converge towards the corresponding phloem groups of the other cotyledon, and the four groups fuse together (fig. 6). The two phloem bundles thus formed are the phloem archs of the root structure.

At the point of fusion of the cotyledonary sheath and the axis, the xylem has become extended laterally, due to the development of flanges of metaxylem on either side of the protoxylem (fig. 8). This change in configuration from the xylem of the cotyledonary bundle is due to the fact that the metaxylem passes downwards on either side of the protoxylem at a more oblique angle than the protoxylem. The metaxylem continues its passage inwards, relative to the protoxylem, until the exarch condition is attained (fig. 11). In one instance the xylem of a lateral bundle appeared to leave the phloem and add to the metaxylem of the median bundle, but, as a rule, the xylem elements of the lateral bundles became non-lignified at the transition level and their path could not be traced definitely. In the upper hypocotyl a secretory duct lies at the outer border of each phloem group, but when root structure is attained the ducts lie at the periphery of the stelar tissues. The transition distance is very short, the distance between the sections represented by fig. 7 and fig. 11 being only 0·30 mm., so that the hypocotyl has vascular structure typical of the root throughout the greater part of its length.

The root structure is a continuation of that of the lower hypocotyl. The two xylem archs, connected by the development of metaxylem, are in the cotyledonary plane, and the phloem archs alternate with them. The six secretory ducts lie at the periphery of the stelar tissues.



FIGS. 1–6.—Diagrams based on camera lucida drawings of serial sections of the hypocotyl. (×40.)

(Black = xylem, stippled = phloem, secretory ducts indicated by circles.)
Distances between the sections represented:

Figs. 1–2 = 0·36 mm.
Figs. 2–3 = 0·06 mm.
Figs. 3–4 = 0 08 mm.
Figs. 4–5 = 0·12 mm.
Figs. 5–6 = 0·04 mm.

FIGS. 7–11.—Camera lucida drawings showing the passage of the xylem from cotyledon to root structure. (×240.)

(Circles = xylem elements, dotted line = limit of phloem.)
Distances between the sections drawn.

Figs. 7– 8 = 0·12 mm.
Figs. 8– 9 = 0·04 mm.
Figs. 9–10 = 0 10 mm.
Figs. 10–11 = 0 04 mm.

Fig. 7 shows details of xylem in fig. 2—protoxylem endarch.
Fig. 8 shows details of xylem in the section preceding fig. 4—flanges of metaxylem on either side of protoxylem.
Fig. 9 shows details of xylem in the section succeeding fig. 4—flanges of metaxylem passing towards the centre of the axis.
Fig. 10 shows details of xylem in fig. 5—protoxylem exarch.
Fig. 11 shows details of xylem in fig. 6—protoxylem exarch.

The Root.

The year-old root (Pl. XXV, fig. 1) has a tegumentary system of corky tissue produced by a well-developed cork-cambium arising towards the periphery of the cortex. Between the cork-cambium and the wood-cambium is developed a wide area of tissue composed of strands radiating from the xylem archs, and consisting of small, closely packed cells rich in starch and containing secretory ducts; alternating with these radiating strands are larger, loosely packed cells in which starch is less abundant or absent.

The older root, in transverse section, has the appearance of an iris-diaphragm (Pl. XXV, fig. 2). The radiating strands of closely packed starchy cells are strongly convoluted, and schizogenous spaces are developed in the loosely packed tissue alternating with these strands. The formation of these convolutions and spaces, which are initiated on the convex side of the convolutions, is due apparently to the unequal strains set up by the secondary growth between the rigid xylem and the confining cork tissue.

The Leaf.

The glabrous, ternately compound leaves are borne clustered on the crown of the rhizome, and singly on the aerial flowering-shoots. The lower leaves are petiolate, the upper leaves are sessile, and the leaf-bases form sheaths encircling the nodes. The leaf-sheaths and the lower parts of the petioles are reddish in colour due to anthocyanin pigmentation.

The average thickness of the uppermost leaf is 0·18 mm., and of the radical leaves 0·25 mm. The cuticle of the upper epidermis is slightly more developed than that of the lower epidermis. The size of the upper epidermal cells, including stomatal guard-cells, is considerably greater than that of the lower epidermal cells, and over the veins the cells are rounded and deeper (averaging 40 μ) than the ordinary epidermal cells (averaging 21 μ).

The stomata are evenly distributed on the ventral surface of the leaf but are absent at the veins. No stomata occur on the dorsal surface of the leaf. On the dorsal surface and edges of the leaf-tips associated with the vein-endings, hydathodes, varying in number from 10 to 15, are found.

These are similar in structure to the stomata, but seem to be always open.

There is a well-marked differentiation into palisade and spongy mesophyll. A ridge of collenchyma runs above and below each main vein. A large secretory duct lies immediately above and below each vein, with two or three smaller ducts in the phloem and xylem-parenchyma. In the preserved material, sphaeroraphides of calcium sulphate are found, most commonly in the epidermis and spongy mesophyll, and particularly abundant in association with the stomata and hydathodes.

The epidermis of the hollow, ridged petiole is thick-walled, and a few stomata are present. There is collenchyma in the ridges and chlorenchyma in the furrows. The leaf-trace consists of a ring of collateral bundles, one internal to each ridge, and varying in number from 7 to 16. There is a large secretory duct just internal to each collenchyma ridge and one internal to each collateral bundle, besides a varying number (3 to 5) at the periphery of each bundle.

The uppermost leaf and the radical leaves were studied with reference to Zalenski's observations (4) that the higher on a shoot a leaf is placed the more xeromorphic it is. Zalenski appears to have regarded transpiration as a fundamental process and not as a necessary accompaniment of photosynthesis, but his observations on the structural differences between upper and lower leaves are of interest. The uppermost leaf is, on an average, 30 cm., and the basal leaves about 10 cm. from the crown of the rhizome. Each measurement given is the average of ten.

(1) Both upper and lower epidermal cells of the uppermost leaf are smaller than those of the radical leaf.

	Uppermost Leaf.	Radical Leaf.
Depth of upper epidermal cell . .	17 μ	21 μ
Depth of lower epidermal cell . .	14 μ	17 μ

The stomatal length of the uppermost leaf is less than that of the radical leaf.

Stomatal length (uppermost leaf) . .	17 μ
Stomatal length (radical leaf) . .	20 μ

The number of stomata per unit area is greater in the uppermost leaf than in the radical leaf.

Number of stomata per square millimetre (uppermost leaf) .	255
Number of stomata per square millimetre (radical leaf) . .	236

(2) The uppermost leaf has smaller mesophyll cells (average diameter 21 μ) than the radical leaf (average diameter 24 μ).

The uppermost leaf has a greater proportion of palisade mesophyll to spongy mesophyll (2 : 3) than the radical leaf (3 : 5).

(3) There is a greater total length of venation per unit area of leaf surface of the uppermost leaf than of the radical leaf. The uppermost shows an increase of 23 per cent. in the total length of venation compared with the radical leaf.

The uppermost leaf is thus shown to be more xeromorphic than the radical leaves of the same plant.

The Aerial Stem.

The epidermis of the aerial flowering-shoot is thick-walled and cuticularised, and there are a few stomata present. The internodes are slightly fluted; there is collenchyma in the ridges and chlorenchyma in the furrows. In the parenchymatous cortex are well-developed secretory ducts usually opposite the phloem bundles of the stele. The innermost layer of cortex is developed as a starch-sheath.

The vascular system consists of a ring of open collateral bundles, the larger of these lying opposite the collenchyma ridges. As one descends the stem, the number of these bundles increases from internode to internode until a constant number is reached. For instance:

Internode	1	2	3	4	5
Number of bundles	33	38	51	51	51
Leaf-trace bundles entering at each node .		7	9	12	16

The xylem-parenchyma, towards the outer side of each xylem-bundle, and the periphery of the pith are strongly lignified. The cells of this lignified tissue vary in size according to their position. The lignified xylem parenchyma has an average cell-diameter of 12 μ, and a small patch of strongly lignified tissue, internal to each bundle, has an average cell-diameter of 18 μ. The strongly lignified compact tissue between the bundles has an average cell diameter of 20 μ, but towards the centre of the stem the cells are larger (40 μ to 50 μ in diameter), less strongly lignified, and grade into

the parenchyma surrounding the central cavity. The pith contains irregularly placed secretory ducts which, like the other ducts in the stem, branch and anastomose at the solid node.

NODAL ANATOMY.

In the transverse section of an aerial flowering shoot, immediately below the 4th node, there are 49 bundles; these can be differentiated, largely on their xylem characters, into 4 types.

(1) Large bundles, with xylem composed of a large number of small elements, mainly spirally thickened protoxylem. These bundles have entered as leaf-trace bundles at the 4th node.

(2) Medium-sized bundles, with xylem composed of a moderate number of larger elements of which $\frac{1}{4}$ or more are protoxylem, and the rest are pitted metaxylem elements. These bundles have entered as leaf-trace bundles at the 3rd node.

(3) Small bundles, with xylem composed entirely of large metaxylem elements. These are produced by the division of a bundle at the 4th node to allow the entry of a leaf-trace bundle, and they always lie adjacent to that bundle. The dividing bundle probably arises as a leaf-trace bundle entering at the 2nd node, where the leaf is in the same orthostichy as the leaf of the 4th node. Other bundles of this type arise by the division of a bundle in the 3rd node, and pass through the 4th node without fusion or division.

(4) Small or medium-sized bundles, composed of elements of various sizes but less than $\frac{1}{4}$ of protoxylem. These are formed by the fusion of two or more bundles in the 4th node, or by a similar fusion in the 3rd node.

As a rule the leaf-trace bundle enters the vascular cylinder by a gap formed by the division of a leaf-trace bundle from two nodes above. One of the branches fuses with the leaf-trace bundle at the node of entry, and with the other branch at the node below. At the second node below, this leaf-trace bundle in turn divides to allow the entry of a leaf-trace bundle of the leaf entering on the same orthostichy.

This scheme is subject to many variations. The normal arrangement is that, in the internode, each leaf-trace bundle,

which entered at the node above, is separated from the next by three bundles from the internode above, and the fusions and divisions of bundles vary with the circumstances in order to achieve this arrangement.

The variations are:

(1) The leaf-trace bundle from two nodes above
- (*a*) may turn to one side of the incoming leaf-trace bundle, and may or may not fuse with an adjacent bundle;
- (*b*) may divide, and the two branches may pass down without fusion, or one branch may fuse with the incoming leaf-trace bundle, and the other fuse with an adjacent bundle;
- (*c*) if not immediately above an incoming leaf-trace bundle, it may fuse with an adjacent bundle from the internode above.

(2) The leaf-trace bundle from the node above
- (*a*) may pass through the node without fusion;
- (*b*) may fuse with two or more bundles, with the branch of a divided bundle, or with an incoming leaf-trace bundle;
- (*c*) may divide into two branches which may or may not fuse with adjacent bundles.

(3) Bundles produced in the nodes above, by fusions or divisions as indicated in (1) and (2),
- (*a*) may pass through without fusion;
- (*b*) may divide and fuse with adjacent bundles, or fuse wholly with an adjacent bundle.

SUMMARY.

Points in the anatomy of *Ligusticum scoticum* are described:

(1) In the seedling, the transition from cotyledonary to radical vascular structure takes place within 0·3 mm. at the top of the hypocotyl. The phloem groups of the cotyledonary median bundle divide, and the branches fuse with the phloem groups of the lateral bundles in the intercotyledonary plane; the transition from endarch to exarch xylem is achieved by the metaxylem passing down on either side of the protoxylem more obliquely than the protoxylem.

(2) There are curious convoluted radiating strands of starch-

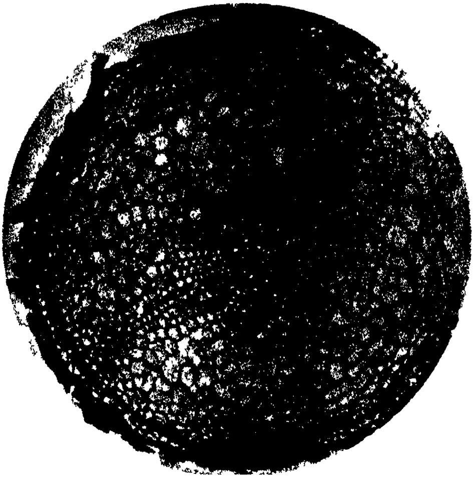


Fig. 1. Microphotograph of year-old root, showing corky tegumentary tissue, cork cambium, and early stages of the formation of secondary starch strands. ×55.

Fig. 2. Microphotograph of older root, showing convoluted radiating strands of starch-filled cells between the xylem core and the confining corky tissue. ×18.

storing tissue in the adult root due to unequal strains set up by secondary growth between the rigid xylem and the confining cork tissue.

(3) The uppermost leaf is shown to be more xeromorphic than the radical leaves.

(4) The nodal anatomy is described, the normal plan indicated, and the exceptions described.

The writer wishes to express his indebtedness for facilities and assistance provided him in the Botanical Department, St. Andrews University, where this investigation was carried out.

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Cork Formation in Veronica Lyallii.

By Ruth Gavine Gray, B.Sc.

(Read 17th June 1937.)

Veronica Lyallii is indigenous to New Zealand and is particularly common in the river beds of South Island. The plant is a prostrate shrub with slender, diffusely branched stems about a foot long, and the phyllotaxis is opposite and decussate. Bark is found round the stem and leaf bases; it is green and smooth in the young stem and brown in the old stem.

Each expanded internode of the stem has two vertical rows of hairs and in successive internodes the rows of hairs are at right angles (fig. 1). The hairs have their origin in the leaf bases; they are formed on the flanges of the leaf bases immediately before the latter fuse with each other round the stem. The row of hairs is the same width for the greater part of its length. The hairs are multicellular and are suberised when fully developed. Each hair arises as a papilla from one epidermal cell which later divides by a radial wall so that the hair appears to originate between two epidermal cells (fig. 3). Hairs are present in a very young stem, and in one set of serial sections of an apex they first appeared at the stage when the youngest axillary bud was visible and the leaf bases of the second pair of leaves had fused.

The most interesting feature of the anatomy of this stem is the origin and development of the hypodermal layers. The hypoderm first appears in the leaf bases immediately under the piliferous part of the epidermis (fig. 7). As the leaf bases never fuse simultaneously at both sides of the stem a hypoderm may be well-developed at the side of the stem where fusion has occurred before it has been differentiated at the other side. There is no connection between the hypoderm and the hairs except that both arise in the same relative position and at the same time at each node. Mature hairs, however, are found in younger parts of the stem than the hypoderm.

In a stem about one year old the cortex consists of about twelve rows of cells. The outer part is collenchymatous, while the hypodermal layer is suberised. The hypoderm is formed by a division of the sub-epidermal layer. The daughter cell next the epidermis enlarges radially and the four walls become suberised. The other daughter cell derived from the division

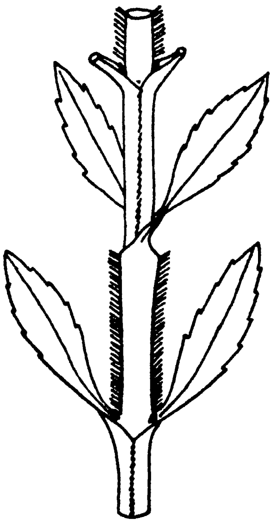


FIG. 1.—External appearance of stem of *Veronica Lyallii*, showing three nodes with bands of epidermal hairs.

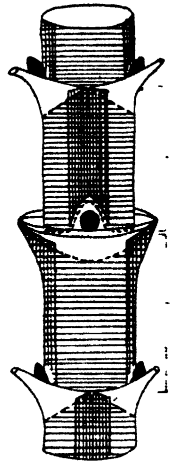


FIG. 2.—Diagram of the distribution of the hypoderm and epidermal hairs in successive nodes of *Veronica Lyallii*, and of their relations to the bud. Hypoderm, single shading; hairs, cross-hatched; bud, solid black.

has the same tangential diameter as the suberised cell, but it does not enlarge radially. The walls of this residual living cell are cellulosic (fig. 3).

The next layer of the cortex consists of cells identical with those of the first hypodermal layer, but here the residual cells are usually in two rows, the inner of which is cellulosic while the outer is suberised (fig. 4). The remainder of the cortex consists of parenchyma. Starch is present in the greater part of the cortex. The suberised cells of the hypoderm do not contain starch but the residual living cells do.

Just above the node the hypoderm begins to disappear opposite the petioles of the pair of leaves at that node (figs.

5, 6). When the leaf bases fuse the hypoderm has completely disappeared from the stem (fig. 7). It reappears in the fused flanges of the leaf bases and gradually surrounds the stem once more (figs. 8–13). The hypoderm growth-pattern may

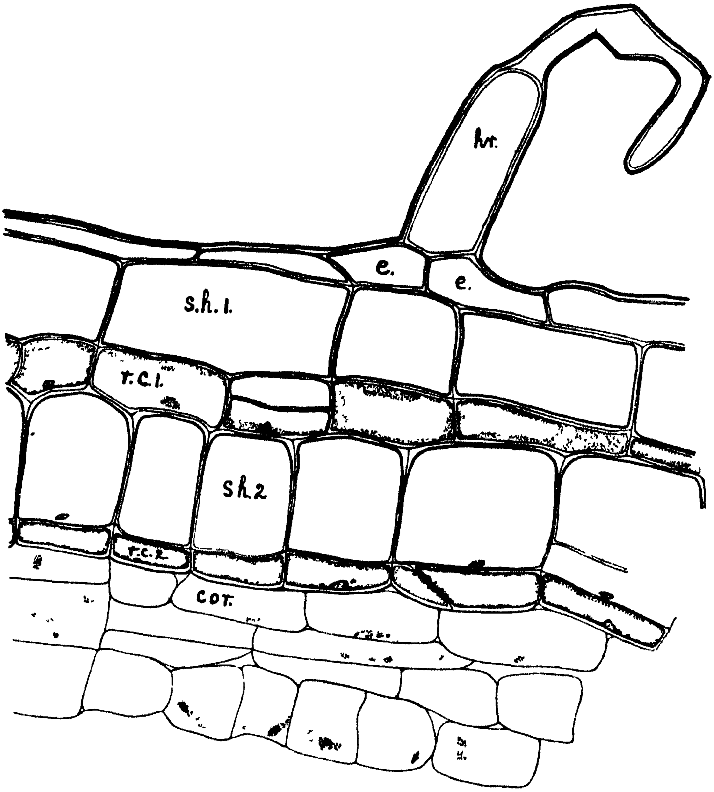


FIG. 3.—Longitudinal section of stem of *Veronica Lyallii* showing two layers of hypoderm, each with one row of residual living cells. (See fig. 4.) Epidermis, *e*; hair, *hr*; suberised hypodermal cells, *s.h.* 1 and *s.h.* 2; residual living cells, *r.c.* 1, and *r.c.* 2; cortex, *cor.*

be divided into units, the unit being a node and the internode immediately beneath it. After a certain age, therefore, the stem is clothed by a discontinuous hypoderm, the interruptions occurring at the nodes (fig. 2).

In older stems three or more corky layers may be present, and later the phellogen becomes patchy. It goes continually deeper into the cortex but never becomes stelar. There

does not appear to be a connection between the age of the stem and the number of corky layers present. It is difficult to determine the age of the plant since it is a perennial and growth is almost continuous, and no definite regular growth-rings are found in the wood.

The hypoderm appears to be equivalent to a very inactive phellogen which makes only one row of cork cells. The under-

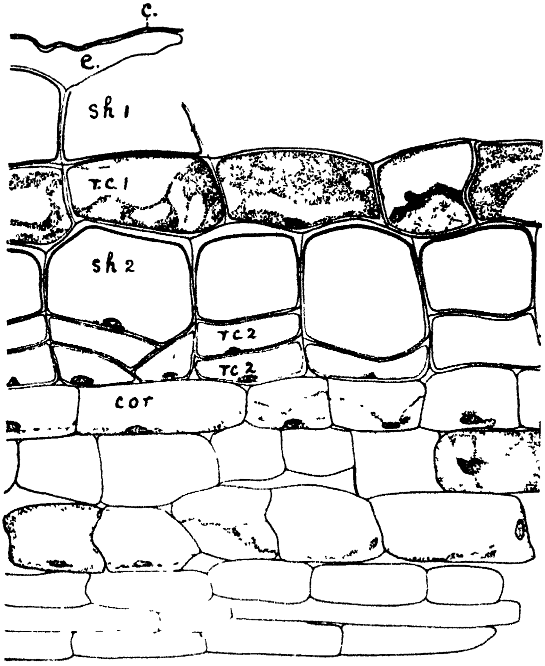
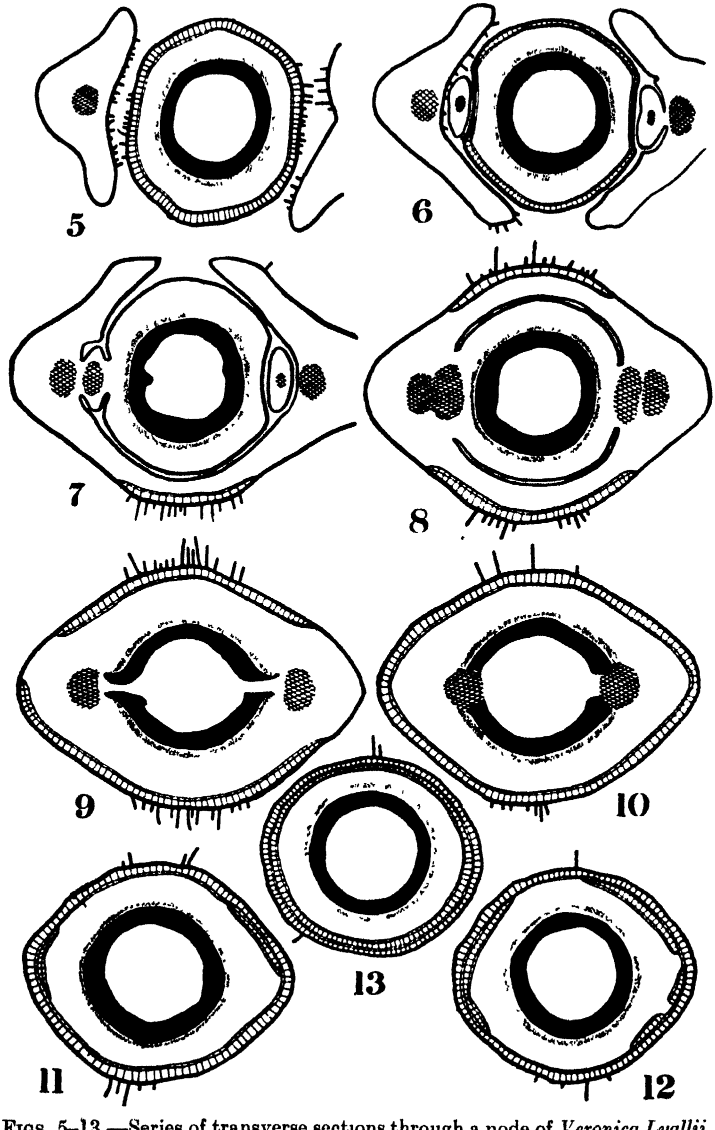


FIG. 4.—L.S. stem of *Veronica Lyallii*, showing epidermis (*e*) with cuticle (*c*).

First hypoderm, with suberised cells, *s.h.* 1; residual living cells, *r.c.* 1; second hypoderm, with suberised cells, *s.h.* 2; residual living cells, *r.c.* 2, some showing second division, cortex, *cor*.

lying layer of cortical cells also acts as a phellogen when necessary; it forms one row of cork cells towards the outside and towards the inside one row of cells which may correspond to phelloderm. Only a few of the latter cells are formed in the first layer of hypoderm, but succeeding layers usually have a complete row.

In regard to the disappearance of the hypoderm above the node, the first signs of this are seen on the mid-line immediately



FIGS. 5–13.—Series of transverse sections through a node of *Veronica Lyallii*, showing the first hypodermal layer (fig. 5), its disappearance opposite the axillary bud (figs. 6, 7), reappearance in leaf bases (figs. 8, 9, 10), origin and development of second hypodermal layer (figs. 11–13).

Key to shading.—phloem, stippled; xylem, black; bud-meristem and leaf-trace, cross-hatched.

above the developing axillary bud (fig. 2). This can be explained on the grounds that the bud-rudiment remains embryonic, while the stem above it, although actually younger, has become fully differentiated. The shape and limits of the meristematic bud-rudiment explain the "tapering-off" of the hypodermal layer above and around it. The same argument explains the similar "tapering-off" of the band of epidermal hairs which takes place above a node. The hairs also begin to disappear along the mid-line, receding from the area occupied by the bud-rudiment.

This type of periderm formation is comparable to the "etagenkork" seen in some Monocotyledons (Philipp, Maria. Über die verkorkten Abschluszgewebe der Monokotylen. Bibl. Bot., 1923), but does not appear to have been recorded in a Dicotyledon.

This work was done in the Botany Department, University College, Dundee, and the writer wishes to thank the Staff for their assistance and co-operation.

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Notes on the Flora of Loch Harray and Loch Stenness and a Comparison with the Brackish-water Lochs of North Uist. By Mary D. Dunn, B.Sc.

(Read 17th June 1937.)

Collections of plants were made by Miss E. A. T. Nicol, B.A., Ph.D., in two brackish-water lochs in Orkney in July 1936, and in a number of lochs in North Uist during the summer of 1935. These were handed over to the Botanical Department of St. Andrews University for identification, and Dr. Nicol very kindly allowed them to be used for a short paper.

The Orkney lochs are shallow—averaging 6 feet deep—with muddy bottoms, and the shores are mostly of fragments of Stromness flagstone. The collecting was carried out at several places at the extreme north end of Loch Harray, near Bankhead and the Mill of Rango. Also at two stations at the south of this loch, near the Bridge of Brodgar, which separates it from Loch Stenness. Collections were made in Loch Stenness on the opposite side of this bridge and round the south-east side of the loch to the outlet at the Bridge of Waithe, and also at two stations far up the loch to the west.

Loch Harray has a very low salinity, being nearly fresh-water at the north end—salinity 0·8 to 0·9 per cent.—and only appreciably salt at the mouth where the water from Loch Stenness overflows into it at high tides: the ordinary tides do not affect the level of the water. Here the salinity varies from 1·4 to 2·8 per cent., while the bottom salinity may be as high as 4·3 per cent.

It is only at this part, near the Bridge of Brodgar, that a few marine algae are found, all of which are associated with brackish water; the rest of the flora being purely freshwater.

Many aquatic Phanerogams are found, including:

Myriophyllum alterniflorum DC.
Littorella lacustris L.
Menyanthes trifoliata L.

Juncus balticus Willd.
Potamogeton heterophyllus Schreb.
,, *lucens* L.
,, *praelongus* Wulf.
,, *filiformis* Pers.
Ruppia maritima L.

The last is found only in the salter water near the mouth, associated with *Myriophyllum* and *Littorella* which are common at all parts of the loch. The others in the list are found in the fresher water towards the north, where also are found:

Equisetum palustre L.
Fontinalis antipyretica L.

The algal flora at the north end of the loch includes:

Chara aspera Willd. var. *subinermis* Kütz.
,, *baltica* Bruzel.
Cladophora holsatica Kütz.
,, *flavescens* Harv.
Spirogyra spp.
Zygnema spp.

The bottom of the loch is here largely covered with *Cladophora holsatica*. It is in the attached form, no floating aegagropilous balls being found, masses of detached cushions being cast up on the shore. *Chara baltica* was dredged along with this *Cladophora*. Species of *Spirogyra* and *Zygnema* are found mixed with other plants at most parts of the loch.

At the salter part towards the mouth the algae include:

Chara delicatula Agardh var. *annulata*.
Fucus ceranoides Linn. var. *linearis* Batt.
Chaetomorpha linum Kütz.
Cladophora flavescens Harv.
Enteromorpha intestinalis Link.
Rivularia Biasolettiana Menegh.

Anabaena variabilis Kütz. is found everywhere in the plankton collections.

Loch Stenness has a much higher salinity than Loch Harray, varying from 9 per cent. to 17 per cent. at the surface,

while the bottom salinity rises to 26·8 per cent. near the outlet. The flora differs correspondingly from that of Loch Harray, being much more marine in character, and including only one Phanerogam—*Ruppia maritima*, which is found at several places, but not in the saltest part.

The list of algae growing round the loch (apart from those dredged) includes:

Furcellaria fastigiata Lamour.
Fucus serratus Linn.
,, *vesiculosus* Linn.
,, *ceranoides* Linn.
Sphacelaria cirrhosa Agardh var. *fusca* Holm et Batt.
Elachistea fucicola Fries.
Chaetomorpha linum Kütz.
,, *litorea* Cooke.
Cladophora flavescens Harv.
,, *fracta* Kütz.
,, *rupestris* Kütz.
Enteromorpha intestinalis Link.

The Greens and *Fucus ceranoides* are generally distributed, the other two species of Fucus being found only close to the outlet of the loch. *Fucus ceranoides* at this part has two epiphytes, *Elachistea fucicola* and *Sphacelaria cirrhosa* var. *fusca*. *Furcellaria fastigiata* is common, occurring far up the loch to the north-west, as well as near the junction with Loch Harray and near the outlet of Loch Stenness, these collecting places all having a salinity of 15 per cent. or over.

Dredging was carried out in Loch Stenness, near Bridge of Brodgar, where the bottom salinity varies from 17·6 to 23 per cent. A dense mass of mixed weeds was obtained, consisting principally of *Chaetomorpha linum* and *Sphacelaria cirrhosa* var. *fusca* along with *Furcellaria fastigiata*, and small parts of the following:—

Callithamnion tenuissimum Kütz.
Polysiphonia urceolata Grev.
Ectocarpus confervoides Le Jol.
Cladophora rupestris Kütz.

A hundred yards west from this dredged samples were taken and a pure mass of *Polysiphonia urceolata* was got, as

well as a mixed collection of Chaetomorphas and Cladophoras. In this sample there was commonly found small plants of *Callithamnion tenuissimum* epiphytic on *Chaetomorpha linum.*

Near the outlet from Loch Stenness, where the bottom salinity rises to 26·8 per cent., *Fucus serratus* and *F. ceranoides* were got by dredging, along with a mixed collection containing small pieces of *Enteromorpha clathrata* Agard. and *Ceramium rubrum* Agard. additional to the species in the other dredged samples.

The lochs in North Uist are much more varied both in depth and in salinity than the Orkney lochs. At low water some of those nearest the sea may be only 8 to 10 inches deep, while others average 25 feet. The salinities vary from 1·2 to 34 per cent.

The flora (1) shows a greater variation, that of the outer basins where the salinity is high being marine in character and including all the marine algae in the Orkney collection, with the exception of *Callithamnion tenuissimum* and *Polysiphonia urceolata*, and also the following additional species:—

Catenella repens Batt.
Ahnfeltia plicata Fries.
Chondrus crispus Lyngb.
Halidrys siliquosa Lyngb.
Pelvetia canaliculata Dcne. et Thur.
Ascophyllum nodosum Le Jol.
Laminaria saccharina Lamour.
Chorda Filum Lamour.
Spermatochnus paradoxus Kütz.
Cladophora Balliana Harv.
Ulva lactuca Linn. var. *latissima* DC.
Percursaria percursa Rosenv.
Vaucheria litorea Bang et Agardh.

In the fresher lochs, where the salinities correspond with those of the Orkney lochs, the algal flora of the two islands is much alike. Three species collected in Orkney are not found in North Uist:

Chara aspera var. *subinermis.*
,, *baltica.*
Rivularia Biasolettiana.

Two additional species found in North Uist are:

Lamprothamnium papulosum Groves.
Monostroma undulatum Wittr.

In conclusion I wish to thank Dr. Nicol for the use of the material, and Mr. Tandy of the British Museum for determining *Cladophora holsatica* and confirming the determination of *Fucus ceranoides* var. *linearis*.

Reference.

(1) Nicol, E. A. T.: The Brackish-water Lochs of North Uist. Proc. Roy. Soc. Edin., lvi (1936), 169–95.

THE SCOTTISH ALPINE BOTANICAL CLUB EXCURSION, 1936. By ROBERT MOYES ADAM, F.L.S. (With Pls. XXVI, XXVII.)

(Read 21st October 1937.)

Blair Atholl was the chosen centre, and the Club assembled there on the afternoon of 17th July. The first excursion was to Loch Tummel, picturesquely situated about twelve miles from Blair. The route was through the Pass of Killiecrankie and across the Bridge of Garry to Strath Tummel, revealing the splendid timbered slopes of this part of Perthshire.

At Loch Tummel a halt was made at the Farm of Borenich, and the party descended through meadows brightened by moorland flowers to the shore where the rare rush *Schoenus ferrugineus* was found quite plentifully over a circumscribed area close to the water (Pl. XXVI). Here it was that this species was first discovered in Britain by Mr. Brebner of Dundee in 1884. In habit and growth the rush resembles its relative *Schoenus nigricans*, the plants forming dense tufts. Intermingled with *S. ferrugineus* were quantities of *Molinia coerulea* and species of *Scirpus* and *Juncus*, growing upon a substratum composed of muddy sand and gravel which is apparently submerged when the loch level rises. Many other marsh species were noted in the vicinity.

After a stay of some hours the party proceeded towards Kinloch Rannoch, passing on the way the works of the new Grampian Hydro-Electric Power Scheme which spoil the landscape by a series of ferro-concrete dams and buildings. The bulk of the River Tummel water is now diverted to pass along an aqueduct above the river bed to reach a power house. This huge structure has been erected close to the fine old "Wade" bridge, while the river below is almost dry and waterless. Beyond Tummel Bridge towards Loch Rannoch the engineers' handiwork is screened by plantations of Conifers and other trees, but later reappears near the outflow from Loch Rannoch. The dam which has been constructed across the Tummel piles up the river so that the

formerly swift-flowing stream resembles the sluggish reach of a canal.

A great strand of gravel near Kinloch Rannoch was found to be interesting ground as quite a host of unusual plants have established themselves over this area. The party then proceeded westward to Rannoch Station and from there explored some very wet and boggy moorland to the south of the station, where a fine colony of *Scheuchzeria palustris* was discovered. The plants were carrying immature green fruits which become yellow when ripe. Gathering darkness now necessitated a retreat to the base at Blair.

Overnight a thunderstorm raged and sent all the hill streams down in high flood. The Tilt which had been at its lowest level was now a raging torrent. These conditions did not however deter the party, and shortly after breakfast two fully loaded cars set off for Glen Tilt. On this occasion the courtesy shown to the party was in contrast to the treatment accorded to Professor J. H. Balfour and his students in 1846. That reception was so stormy that it was called "The Battle of Glen Tilt" and was recorded in verse.

The cars were left about two miles beyond Forest Lodge and the remainder of the journey was completed on foot. The drive so far had revealed much of the beauty of this Atholl glen. The lower reaches are made interesting by the deep defile which the river has cut for itself and by the luxuriant vegetation that clothes the sides. Fine woodland and specimen trees are a feature, and are much in evidence in the valley and parkland at Blair Castle. The upper parts of the valley show less woodland, and grassy slopes with good grazing take its place. Still farther up, in the region of Forest Lodge, heath dominates wide stretches of the valley, broken into, however, at many places by screes of loose rocks; while towards the summit of Beinn a Ghlo very naked regions mark the highest levels.

The party advanced along the Braemar path, but shortly afterwards this had to be abandoned in favour of a route on the east bank of the Tilt where the streams were passable. When the track crossed the lower slope of Meall Gharran the sight of rocks of mica schist spurred the party to examine all likely places, and much time was spent in the process. Thus when An Lochain was reached it was too late in the day

Schoenus ferrugineus in natural habitat, Loch Tummel.

R. M. Adam

Astragalus alpinus growing on rock ledge, Ben Vrackie

R. M. Adam

to ascend the higher crags above Loch Loch, which could be seen only dimly through the mist. The party now divided; one section searched the east bank of the Tilt while the other continued to the Falls of Tarff, crossing the Bedford Memorial bridge. The most interesting plant seen was an exceptionally fine specimen of *Vicia sylvatica*, growing beside the Tilt. The Falls of Tarff were impressive in their flooded state and were much admired.

The following afternoon the weather had improved and allowed some time to be spent at Trinafour and Auchleeks where some fine specimens of *Thymus britannicus* were seen.

The prospects of fine weather the following morning encouraged the Club to make an early start, their first objective being Moulin. Near this village the party left their cars and started the ascent of Ben Vrackie. On the way up a boggy pool yielded some interesting species of *Carex* and *Potamogeton*. The rocks of this mountain are composed of basalt or trap and are rather dry, but when these formations weather a fine soil is formed which supports many kinds of plants. The two outstanding species observed were *Astragalus alpinus* (Pl. XXVII) and *Oxytropis uralensis*. Of the former, hundreds of small plants were mixed with *Festuca ovina* to form a sward. Very few flowers of the *Astragalus* were seen and the plants of *Oxytropis* were all in fruit. The extensive view from the summit was not seen to the best advantage owing to threatening skies. Returning to Blair Atholl a visit was paid to the Castle under the guidance of Mr. Inglis.

The meeting concluded with a visit to the railway embankment between Blair Atholl and Struan, where two uncommon plants were known to grow, namely, *Lepidium heterophyllum* var. *canescens* and *Barbarea intermedia*. Both were seen in fine flower growing on the dry ash. The same afternoon the members went their different ways satisfied with the success of the excursion despite the trying weather conditions.

The following is a list of the noteworthy species met with at Rannoch: *Scheuchzeria palustris* Linn., *Carex magellanica* Lam. At Tummel: *Thymus britannicus* Ronn., *Schoenus ferrugineus* Linn. At Blair Atholl: *Barbarea intermedia* Bor., *Lepidium heterophyllum* Benth. var. *canescens* Gren. et Godr., *Teesdalia nudicaulis* Br. At Glen Tilt: *Sagina nodosa* Fenzl, *Vicia sylvatica* Linn., *Sorbus Aria* Crantz var. *incisa* Reichb.,

Saxifraga umbrosa Linn. var. *crenato-serrata* Bab., *Crepis paludosa* Moench, *Hieracium anglicum* Fr. var. *cerinthiforme* Backh., *Gentiana campestris* Linn., *Euphrasia confusa* Pugsley, *Carex remota* Linn., *C. inflata* Huds. × *C. vesicaria* Linn. At Ben Vrackie: *Draba incana* Linn., *Cerastium alpinum* Linn., *Astragalus alpinus* Linn., and *Oxytropis uralensis* DC.

Report of the Annual Conference of the Cryptogamic Section, 1937.

By Rupert Smith.

(Read 21st October 1937.)

The Cryptogamic Section of the Society held the Fifty-sixth Annual Conference at Elgin on the 21st to 24th September 1937, with headquarters at the Station Hotel. Five members and one visitor were present.

The plain of Moray is mainly composed of sandstone of the Old Red Epoch, but towards the coast it is heavily coated with diluvium, which around Elgin is sand. The whole district is well wooded and enjoys the temperate climate of the Moray Firth.

On Tuesday, 21st, a very pleasant day was spent on the estate of the Duke of Richmond and Gordon at Fochabers. Under the guidance of Mr. Clark, the head forester, the party was taken to the most suitable ground for its purpose, and a good variety of fungi was collected. He also drew attention to many specimens of trees, and particularly to a large walnut loaded with fruit and to a very handsome lime.

On 22nd the woods at Pitgaveny, about two miles north of Elgin, were visited. This estate belongs to Capt. J. Brander Dunbar, who accompanied the party in the foray. It was one of the warmest days of the season and the shade of the woods was very acceptable. Pitgaveny is the place to which local tradition assigns the murder of King David by Macbeth.

Two estates were visited on Thursday, 23rd, viz. the Dallas estate of Major Houldsworth, and the oak woods in the vicinity of Elgin. These woods are extensive, but oak does not predominate; in fact, there is more beech than oak. They have been recently purchased by an Elgin manufacturer in order to preserve them as an amenity to the town.

During the forays the party was favoured with perfect weather and had a very enjoyable and profitable sojourn.

A good variety of fungi was collected, among the less

common being *Geoglossum viride*, a Discomycete of a verdigris green colour from 2 to 3 inches in height and growing among moss, *Cordyceps ophioglossoides* parasitic on the tuber *Elaphomyces granulatus*, *Otidea leporina*, *Lactarius uvidus*, and a rather uncommon *Coprinus hemerobius*.

It was arranged to hold the Fifty-seventh Conference next year at Kelso.

LIST OF SPECIES GATHERED DURING THE FORAY.

Localities.

Fochabers, 21st September.
Pitgaveny, 22nd September.
Dallas, 23rd September.
Elgin, 23rd September.

HYMENOMYCETES.

Amanita muscaria (Linn.) Fr.; spissa Fr.; pantherina (DC.) Fr.; mappa (Batsch) Fr.; rubescens (Pers.) Fr.

Amanitopsis vaginata (Bull.) Roze; fulva (Schaeff.) W. G. Sm.

Lepiota granulosa (Batsch) Fr.; cristata (A. et S.) Fr.; procera (Scop.) Fr.; amianthina (Scop.) Fr.

Armillaria mellea (Vahl) Fr.

Tricholoma rutilans (Schaeff.) Fr.; columbetta Fr.; terreum (Schaeff.) Fr.; albobrunneum (Pers.) Fr.

Clitocybe albo-cinerea Rea.; geotropa (Bull.) Fr.; clavipes (Pers.) Fr.; aurantiaca (Wulf.) Studer; fragrans (Sow.) Fr.

Laccaria laccata (Scop.) B. et Br.; var. amethystina (Vaill.) B. et Br.

Collybia radicata (Relh.) Berk.; velutipes (Curt.) Fr.; maculata (A. et S.) Fr.; butyracea (Bull.) Fr.

Mycena metata Fr.; galericulata (Scop.) Fr.; epipterygia (Scop.) Fr.; pura (Pers.) Fr.; galopus (Pers.) Fr.; rosella Fr.

Omphalia fibula (Bull.) Fr.

Pleurotus porrigens (Pers.) Fr.

Pluteus cervinus (Schaeff.) Fr.

Clitopilus prunulus (Scop.) Fr.

Nolanea pascua (Pers.) Fr.

Pholiota spectabilis Fr.; squarrosa (Mull.) Fr.; mutabilis (Schaeff.) Fr.; aurea (Mattusch) Fr.

Inocybe geophylla (Sow.) Fr.; hystrix Fr.; rimosa (Bull.) Fr.

Hebeloma crustuliniforme (Bull.) Fr.; fastibile Fr.

Flammula sapinea Fr.

Naucoria melinoides Fr.; semiorbicularis (Bull.) Fr.

Galera hypnorum (Schrank) Fr.

Crepidotus mollis (Schaeff.) Fr.

Psalliota sylvatica (Schaeff.) Fr.

Stropharia semiglobata (Batsch) Fr.; aeruginosa (Curt.) Fr.; squamosa (Pers.) Fr.

Hypholoma fasciculare (Huds.) Fr.; sublateritium (Schaeff.) Fr.; dispersum Fr.

Psilocybe semilanceata Fr.

Panaeolus campanulatus (Linn.) Fr.

Psathyrella gracilis Fr.

Coprinus comatus (Fl. Dan.) Fr.; hemerobius Fr.; micaceus (Bull.) Fr.; atramentarius (Bull.) Fr.; ephemerus (Bull.) Fr.; plicatilis (Curt.) Fr.

Cortinarius (Dermocybe) cinnamomeus (Linn.) Fr.; (Inoloma) violaceus (Linn.) Fr.; tabularis (Bull.) Fr.; cinnabarinus Fr.; caninus Fr.; (Mhyxacium) elatior Fr.; (Telamonia) hinnuleus (Sow.) Fr.; torvus Fr.; (Hydrocybe) castaneus (Bull.) Fr.; acutus (Pers.) Fr.

Gomphidius glutinosus (Schaeff.) Fr.

Paxillus involutus (Batsch) Fr.

Hygrophorus pratensis (Pers.) Fr.; ceraceus (Wulf.) Fr.; psittacinus (Schaeff.) Fr.; puniceus Fr.; conicus (Scop.) Fr.; chlorophanus Fr.

Lactarius torminosus (Schaeff.) Fr.; blennius Fr.; glyciosmus Fr.; quietus Fr.; vellereus Fr.; mitissimus Fr.; turpis (Weinm.) Fr.; lilacinus (Lasch.) Fr.; deliciosus (Linn.) Fr.

Russula fellea Fr.; emetica (Schaeff.) Fr.; rosacea (Pers.) Fr.; nigricans (Bull.) Fr.; drimeia Cke.; atropurpurea (Krombh.) Maire; foetens (Pers.) Fr.; cyanoxantha (Schaeff.) Fr.; ochroleuca (Pers.) Fr., fragilis (Pers.) Fr.; rubra (Krombh.).

Cantharellus cibarius Fr.; tubaeformis Fr.

Marasmius peronatus (Bolt.) Fr.; dryophilus (Bull.) Karst.; hariolorum (DC.) Quél.

Boletus badius Fr.; luridus (Schaeff.) Fr.; luteus (Linn.) Fr.; chrysenteron (Bull.) Fr.; edulis (Bull.) Fr.; reticulatus (Schaeff.) Boud.; elegans (Schum.) Fr.; piperatus (Bull.) Fr.; subtomentosus (Linn.) Fr.; bovinus (Linn.) Fr.

Polyporus hispidus (Bull.) Fr.; betulinus (Bull.) Fr.; lentus Berk.

Fomes annosus Fr.

Polystictus versicolor Fr.; zonatus Fr.

Daedalea quercina (Linn.) Fr.

Merulius lacrymans (Wulf.) Fr.

Hydnum repandum (Linn.) Fr.

Tremellodon gelatinosum (Scop.) Pers.

Irpex obliquus (Schrad.) Fr.

Stereum purpureum (Pers.) Fr.; hirsutum (Willd.) Fr.

Clavaria corniculata (Schaeff.) Fr.

Calocera cornea (Batsch) Fr.; viscosa (Pers.) Fr.

Dacryomyces deliquescens (Bull.) Duby.

GASTEROMYCETES.

Phallus impudicus (Linn.) Pers.

Lycoperdon echinatum Pers.; perlatum Pers.; pyriforme (Schaeff.) Pers.; excipuliforme (Scop.) Pers.; saccatum (Vahl.) Fr.

Scleroderma aurantium Pers.; verrucosum (Vaill.) Pers.

PYRENOMYCETES.

Xylaria Hypoxylon (Linn.) Grev.; carpophila (Pers.) Fr.

Nectria cinnabarina (Tode) Fr.

Cordyceps ophioglossoides (Ehrh.) Link.

DISCOMYCETES.

Geoglossum viride (Pers.) Fr.

Trichoscypha calycina (Schum.) Boud.

Rhytisma acerinum (Pers.) Fr.

Stegia Ilicis Fr.

Peziza aurantia Pers.; also var. atro-marginata; micropus Pers.

Otidea leporina (Batsch) Fuck.

Bulgaria inquinans (Pers.) Fr.

Phialea strobilina (Fr.) Sacc.; fructigena (Bull.) Gill.

Helotium fagineum (Pers.) Fr.

Lachnella diminuta Rob.

Chlorosplenium aeruginosum (Oeder.) De Not.

Sclerotinia Curreyana (Berk.) Karst.

PLECTASCALES.

Elaphomyces granulatus Fr.

TRANSACTIONS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CII

NOTES ON THE PLANTS OF THE NORTH-WESTERN PENINSULA OF ICELAND. By H. R. FLETCHER, B.Sc., Ph.D. (With Pl. XXVIII.)

(Read 16th December 1937)

The following notes are the results of observations made in the North-West Peninsula of Iceland during July and August of 1937, when the writer was a member of the St. Andrews University Expedition to that region.

The Expedition was organised with the object of forming a suitable base camp on the south coast of the Peninsula, from which small mobile parties would be sent out in different directions. A peninsula called Vattarnes was selected as the base, and two fairly long journeys into the country were made. The map illustrating these notes marks the routes taken by the various biological parties during these journeys. Whilst gaining some idea of the vegetation as a whole, the areas to which the botanists confined most of their attention were the plateaux regions behind the base camp, between the base and Brjanslaekur, and between Hagi and Foss, the coast between Brjanslaekur and Brekkunellir, the high mountain region behind Alftamyri, and the hot springs at Laugabol. Consequently in these notes, in addition to giving a general survey

of the vegetation of the Peninsula, the components of the following types of vegetation are discussed:—

1. Vegetation of the plateau.
2. Vegetation of the valleys and the high mountains typified by Fossdalur and Kaldbakur, the highest mountain of the N.W. Peninsula.
3. Sand-dune vegetation at Brjanslaekur and Hagi.
4. Hot Spring vegetation at Laugabol.

As time and opportunity were not available for studying the physiology of these various habitats, the notes can be little more than a compilation of the names of the plants which were found. The plant names are those used by C. H. Ostenfeld and Johs. Grontved in their Flora of Iceland and the Faroes, 1934.

The most striking feature of the plant life of the N.W. Peninsula is its homogeneous character, practically the same type of vegetation prevailing everywhere. On the whole the Peninsula is not rich in species, and certain plants which are predominant in most parts of the country are not to be found in the N.W. For instance, *Fragaria vesca*, *Chamaenerium angustifolium*, *Calluna vulgaris*, *Galium boreale*, and *Senecio vulgaris*, though fairly common all over Iceland, have never been recorded from the N.W. Other species, *Equisetum fluviatile*, *Carex capitata*, *Juncus bufonius*, and *Limosella aquatica*, frequently found over the country, *Prunella vulgaris* common in the S., S.W., N., and E., and *Callitriche verna* abundant in the S. and S W., are all extremely rare in the N.W. On the other hand, certain species fairly common in the N.W. are seldom met with in other districts. *Athyrium alpestre* is only recorded from one locality in the N., one in the S.W., and one in the E.; *Lycopodium annotinum* is absent from the S. and the E., and is elsewhere rare; *Lycopodium alpinum* is uncommon in the E. and has not been recorded from the S.; plants of *Equisetum hiemale* occur in very small numbers in the E. and S.; *Myosotis micrantha*, rare in the N. and S., has not been recorded in the E.; yet all those plants are common in the N.W. Peninsula. Other species again are absent from the entire island except for one or two localities in the N.W. *Stellaria borealis* at Vatnsfjordur, *Melampyrum silvaticum* at Langabolsdalus and Isafjardardalur, *Veronica chamaedrys* at Onundarfjordur, *Hieracium kaldalonense* at

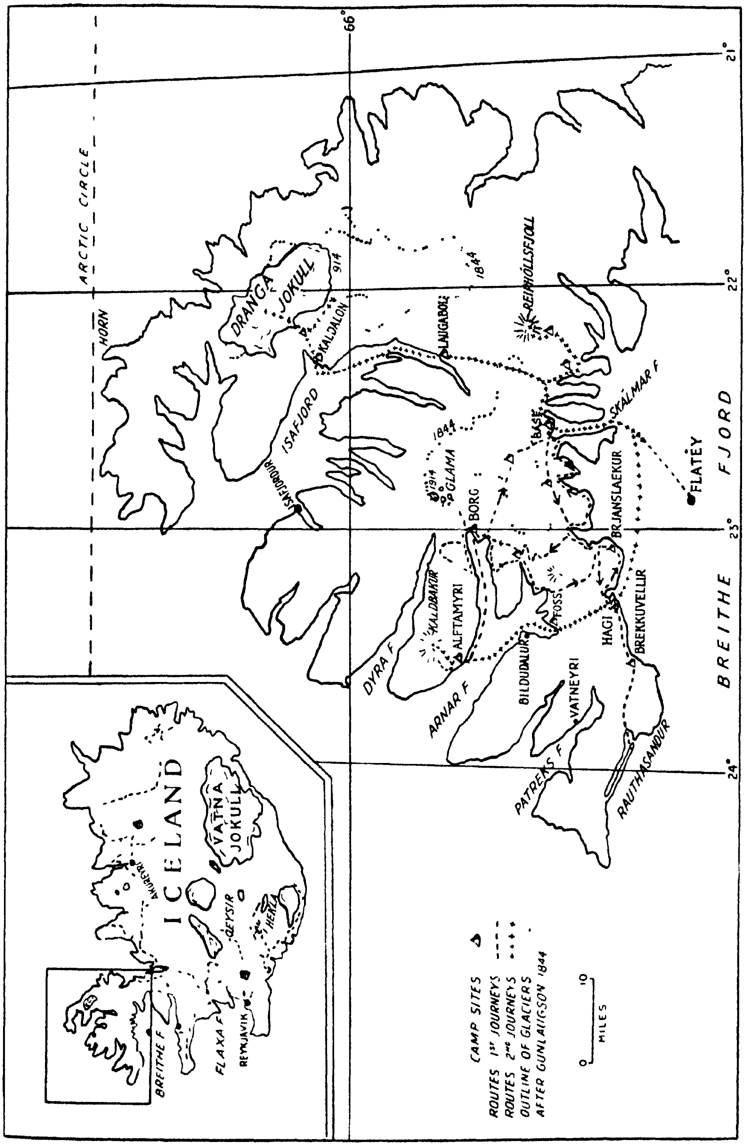
Kaldalon and Reykjarfjardardalur, *Hieracium lygistodon* at Vallreskinn near Reykjarfjordur, *Luzula sudetica* and *Orchis latifolius* at Kaldalon, *Cryptogramma crispa* from Hesteyri in Vestfirdir, and *Equisetum silvaticum* at Heydalur are species in question.

The vegetation is essentially European, though several species common on the N.W. Peninsula are absent from the British Flora. *Ranunculus glacialis* and *Ranunculus pygmaeus*, conspicuous near glaciers and melting snow, *Ranunculus hyperboreus* and *Ranunculus paucistamineus* var. *eradicata*, common ditch plants, *Cassiope hypnoides*, on all the plateaux, *Gentiana campestris* subsp. *islandica*, *Gentiana amarella* f. *subarctica*, *Gentiana tenella*, *Gentiana detonsa*, *Gentiana aurea*, *Pleurogyne rotata* and *Myosotis micrantha*, by no means rare in any part of the country and on sandy grassy slopes often very abundant, *Papaver radicatum*, common in all parts of the country, *Koenigia islandica*, *Epilobium lactiflorum*, *Eriophorum Scheuchzeri* and *Habenaria hyperborea*, abundant in marshy places, and *Betula pubescens*, the only tree of Iceland's so-called woods, are some of the plants which are absent from the British Flora. All these inhabit Scandinavia, and a few, *Gentiana detonsa* and *Pleurogyne rotata* for example, are decidedly Arctic. The scarcity of truly Arctic species on the N.W. Peninsula is very noticeable and may be partly accounted for by the Arctic current being diverted from the shores of Iceland by the Gulf Stream.

But more than the plants themselves it is the distribution of the various species which is of the greatest interest, and herein lies the most remarkable difference between the flora of Iceland and that of Great Britain. In the first place, a few species very rare in Great Britain, and in their known localities often confined to very small areas, are in the north-west of Iceland very common and widely distributed. *Ranunculus reptans*, only recorded with certainty from the sandy shores of Loch Leven, is a common plant on the N.W. of Iceland, usually on the margins of sandy pools or growing completely submerged. *Saxifraga rivularis* in Great Britain is found on Ben Lawers, Ben Nevis and at Braemar at an altitude of 3000 ft. and upwards, among wet alpine rocks. In the N.W. of Iceland this plant is to be found on most of the hills growing in marshy places at 300 ft. and upwards.

Saxifraga cernua is confined to Ben Lawers at 4000 ft., whereas at Vattarfjall several plants were found at 1000 ft., and at Kaldbakur a few specimens were seen at 1500 ft., and at 3000 ft. the plant grew in great profusion in the wet crevices of rocks and on loose damp soil. The Breadalbane and Clova mountains are the only recorded habitats of *Gentiana nivalis* in Great Britain. There the plant grows from 2400 to 3300 ft., but in Iceland it is common all over the country, especially in poor grassy heathland. *Veronica alpina* and *Veronica saxatilis* are rare plants on the highest Scottish mountains from 1500 to 3700 ft., whereas in Iceland the former is a common inhabitant of all parts, on heaths, by streams, wet places in the hills and among rocks, from almost sea-level to 2500 ft., and the latter is found in drier places from 50 to 2000 ft. *Cerastium trigynum* is another rare plant growing at high altitudes on Scottish hills and yet being very abundant in Iceland at a few feet above sea-level up to over 2000 ft. *Juncus castaneus* is more common in the N.W. of Iceland than in any other part of the island, often growing in low-lying marshes and bogs, yet in this country it is a very rare plant of alpine bogs from 2500 to 3000 ft.

Other plants again, which in Great Britain have a wide distribution but which are confined to definite associations—coastal and high hill plants for example—grow abundantly in Iceland, irrespective of altitude. For instance, *Saxifraga nivalis*, *Gentiana nivalis*, *Veronica alpina*, *Veronica saxatilis*, *Cornus suecica*, *Silene acaulis*, *Viscaria alpina*, and *Thalictrum alpinum* are all high alpine plants in Great Britain. In Iceland they inhabit high altitudes too, but also grow abundantly at a few feet above sea-level. It is quite impossible to arrange species according to any altitudinal zonation. Consequently it is usual to find a typical plateau plant association growing in the region of the seashore. *Eriophorum polystachyum*, *Luzula arcuata*, *Salix herbacea*, *Papaver radicatum*, *Arabis alpina*, *Draba incana*, *Cerastium alpinum*, *Viscaria alpina*, *Saxifraga caespitosa*, *Saxifraga oppositifolia*, *Saxifraga nivalis*, *Dryas octopetala*, *Sibbaldia procumbens*, *Epilobium anagallidifolium*, *Gnaphalium norwegicum*, and *Gnaphalium supinum* are all common plateau plants which grow, often more luxuriantly, at the coast.



From "Alumnus Chron," St. Andrews University.

H. R. FLETCHER.

Ranunculus glacialis and *Cassiope hypnoides* seem to be the only plants of the North-West Peninsula which, having a fairly wide distribution, yet are confined exclusively to the plateau.

VEGETATION OF THE PLATEAUX.

The plateaux regions we had occasion to cross varied in altitude from 1500 to 2500 ft. The substratum of lava, volcanic gravel and sand is of a very porous nature, and in spite of much precipitation of rain and snow the vegetation is subject to conditions of drought. These plateaux then are deserts of gravel, lava and blown sand. Damp level tracts are often marked with remarkable stone polygons which consist of an irregular network of large stones, infilled with mud and small pebbles, and are apparently caused by the action of frost. In such places the surface of the plateau resembles a net, the meshes of which are formed by the large stones.

For the most part plant growth is of a very stunted and scattered nature. Here and there isolated plants of *Dryas octopetala*, *Silene acaulis*, *S. maritima*, *Armeria maritima*, *Loiseleuria procumbens*, *Potentilla alpestris*, *Cerastium alpinum*, *Saxifraga oppositifolia*, *Oxyria digyna*, *Papaver radicatum*, *Polygonum viviparum*, *Empetrum nigrum*, and *Arabis petraea* occur. Usually plants are found among the stones forming the meshes of the stone polygons. Evidently they are able to find shelter there, but the mud and clay of the interior of the polygons is too wet for plant growth. Many great angular blocks of lava are to be seen. These very often shelter large drifts of gradually melting snow, consequently the vegetation of these blocks is rather richer than that of the rest of the plateau. In addition to the above-mentioned plants, *Alchemilla alpina*, *Saxifraga caespitosa*, and *Viscaria alpina* are invariably to be found. Frequently too, a noteworthy plant of these moist ridges is *Cassiope hypnoides*. Small isolated plants of *Ranunculus glacialis* may sometimes be seen, though usually this plant prefers the glacial mud near the glaciers. Near to melting snow, streams or even minute lakes may occasionally occur, and there one finds that a small green oasis has developed. *Descampsia alpina*, *Poa pratensis* and *Poa alpina*, *Eriophorum Scheuchzeri*, *Saxifraga stellaris*,

Ranunculus hyperboreus, *Cerastium trigynum*, and several *Carices* are constantly to be found in such localities.

Vegetation of the Valley Fossdalur and the Mountain Kaldbakur (3277 ft.).

A study of the map would lead one to believe that Kaldbakur and the neighbouring mountains might have a different structure from the rest of the plateau, for here the tabular mountains of the central plateau are suddenly replaced by sharp-ridged conical peaks. Actually this group of mountains differs very little in structure from the rest of the plateau, being composed of thick layers of basaltic lava, alternating with layers of bauxite and volcanic ash, relics of the soils which covered the lavas between successive eruptions. It would seem that the great difference in form in the mountains of this district may be attributed to a more intense glacial erosion than in other parts of the plateau.

Winding down the middle of the valley Fossdalur, as in almost every other valley, is a river. On either side of the river, marshy grassy flats intermixed with rocky flats slope up to loose screes from which great cliffs and pinnacles rise up amphitheatrically to 2000 to 2500 ft. Kaldbakur is the highest of these pinnacles (3277 ft.). Small streams cascade down the face of the cliffs, and the brilliant green of the mosses which grow in close proximity to the water lend a touch of colour to the otherwise dull brownish grey of the rock. The two most common mosses of these habitats are an aquatic form of *Bryum pallens*, and *Mnium punctatum*. Small drifts of snow are often to be found at the head of the screes at approximately 1000 ft., and though the summit of Kaldbakur was free from snow, great drifts, sheltered by rocky outcrops, were found at 1500 to 3000 ft.

The vegetation of the valley is very luxuriant. Small rocky outcrops near to the water are covered with *Marchantia polymorpha*. *Epilobium palustre*, *E. anagallidifolium*, *E. alsinifolium*, *Saxifraga stellaris*, *S. nivalis*, *S. hypnoides* subsp. *boreali-atlantica*, *Veronica alpina*, *V. fruticans*, *Bartschia alpina*, *Phleum alpinum* and *Salix lanata* are all common by the side of the stream. *Anthoxantheum odoratum*, *Aira caespitosa*, *Festuca ovina*, *F. rubra* and *Phleum alpinum* are

all characteristic grasses of the grassy slopes, large areas of which are occupied by twisted masses of *Betula pubescens*. In marshy places *Tofieldia palustris*, *Triglochin palustris*, *Potentilla palustris*, *Habenaria viridis*, *Koenigia islandica*, *Eriophorum polystachyum*, *Pinguicula vulgaris*, *Menyanthes trifoliata*, *Viola palustris* are the chief plants. Higher up, the grassy slopes are much drier and one finds a larger number of genera and species such as *Salix lanata*, *S. glauca*, *S. herbacea*, *Thymus serpyllum* var. *prostrata*, *Veronica alpina*, *Dryas octopetala*, *Vaccinium myrtillus*, *V. uliginosum*, *Pyrola minor*, *Empetrum nigrum*, *Thalictrum alpinum*, *Viscaria alpina*, *Cerastium trigynum*, *Cerastium alpinum*, *Erigeron borealis*, *Polygonum viviparum* and *Rumex acetosa*. Sometimes all these plants occur in close proximity, whilst at other times one or more grow in such profusion as to dominate large areas. The Salices, the Vacciniums, and Dryas are plants of this nature. Many of these plants of the drier grassy slopes, Viscaria, Cerastium, Dryas, Thalictrum, Salix, and Thyme for example, are also to be found on the screes, but undoubtedly the most common scree plants are *Juniperus communis* and *Betula nana*.

Above 1500 ft. the number of species and of individual plants thins out considerably, though up to 2000 ft. *Dryas octopetala*, *Veronica alpina*, *Cerastium alpinum*, *Viscaria alpina*, and *Erigeron borealis* are represented in the drier places, and *Saxifraga hypnoides* subsp. *boreali-atlantica* and *S. nivalis* in the wetter places. Above this altitude new plants are found. *Ranunculus acer* var. *pumila*, a dwarf mountain variety with solitary large yellow flowers on 1–2 in. stems, *R. pygmaeus*, a buttercup with small inconspicuous flowers, the petals not exceeding the sepals, and *R. glacialis*, with petals at first white and later pink, were not found below 2000 ft. These three plants were very common in wet mud, the latter especially so near melting snow. *Ranunculus pygmaeus* and *R. glacialis* occurred on the summit of Kaldbakur, but by far the most common plant at this altitude of 3277 ft. was *Saxifraga cernua*, which was flourishing both in loose damp soil and in the wet clefts of rocks.

Sand-dune Vegetation at Brjanslaekur and Hagi.

Intermittent stretches of sand-dune occur all along the south coast of the North-Western Peninsula, and though the character of the coastal vegetation is everywhere the same, Brjanslaekur and Hagi were the two spots most suitable for a general survey because they afforded excellent camping sites. At no place along this coast are very extensive sand-dunes developed. Usually there is a narrow belt of dune, followed by a still narrower belt of grassland and then by steep rocky slopes which ascend to the plateau. Many small streams cascade down these slopes, and consequently numerous small pools are to be found on the dunes. These pools are essentially moorland in character.

A notable feature here is the poor development of shifting dunes. In the few places where these occur, *Elymus arenaria* is the only plant to be found. Invariably the strand vegetation is succeeded by a stretch of stable dune which gradually merges into poor grassland. The chief members of the strand association are *Cakile maritima* var. *latifolia* and *Honckenya peploides*, though isolated plants of *Cochlearia officinalis*, *Matricaria inodora*, *Silene maritima* and *Carex incurva* are also to be found. In a few places where the strand is stony instead of sandy, *Mertensia maritima* has gained a hold. On the stable dune *Honckenya* and *Elymus*, *Festuca rubra*, *Thymus serpyllum* var. *prostrata*, and *Galium verum* are dominant, but one of the most characteristic plants is *Potentilla anserina*, the ground being quite interwoven with this plant's red creeping stems. A very dwarf form of *Parnassia palustris*, never more than 2 inches in height, *Botrychium lunaria*, *Gentiana campestris* var. *islandica*, *G. tenella*, *G. nivalis*, *G. aurea* and *Pleurogyne rotata* are all not uncommon plants of the stable dune.

Running across the dune one often finds dry, stony, water courses, and there *Sedum villosum* is invariably seen, together with isolated plants of *Salix glauca* and *S. lanata*, *Galium verum*, *Epilobium palustre*, and others. It was in such a habitat that *Chamaenerium latifolium* was discovered at Brjanslaekur. This plant was also seen in a garden at Hagi, and we were informed by the farmer that he had brought his plant from Brjanslaekur—the only spot where *Chamaenerium* was known to grow naturally on this part of the coast.

The pools referred to are generally to be found on the landward side of the stable dune. *Scirpus palustris*, *Eriophorum polystachyum* and *Hippuris vulgaris* are all common plants in addition to *Ranunculus reptans* and *R. paucistamineus* var. *eradicata*, a plant with multifid, threadlike leaves and small white flowers, the petals of which have a yellow base.

Hot Spring Vegetation at Laugabol.

The hot alkaline springs at Laugabol are being used by a German settler for interesting horticultural experiments. He has divided up his land by a network of irrigation channels, by means of which the ground is heated to some 25° F. above the temperature of the surrounding soil. In this soil all the market-garden produce of warmer climates is being grown with great success. Even tomatoes are flourishing out of doors—within 40 miles of the Arctic Circle! Hot-houses are heated from the springs, and in them cucumbers, marrows, and tomatoes successfully ripen. There is also a large concrete hot water open-air swimming-pool.

The alkaline springs usually contain pure clear water which often deposits siliceous sinter. Consequently the vegetation, unlike that around the sulphur springs, is quite luxuriant, not only in the immediate vicinity of the springs, but for a considerable distance away from them. This is probably because the water vapour from the springs is continually floating above the surrounding ground and descending as a fine rain of tepid water. *Potentilla anserina*, *Leontodon autumnalis*, *Ranunculus acer*, *Gnaphalium uliginosum*, *Polygonum persicaria*, *P. aviculare*, *Plantago major*, *P. maritima*, *Epilobium palustre*, *Aira caespitosa*, *Juncus lamprocarpus*, and *J. bufonius* are regularly to be found in the region of the hot springs. Often stunted forms of common species are very abundant, to name two such forms *Plantago major* f. *pygmaea* and *P. maritima* f. *pygmaea* are by far the most common. *Ophioglossum vulgatum* var. *minus* is a rare plant in Iceland and is found near the hot springs and in no other place; though recorded from the N.W. Peninsula at Reykjaneshver, it could not be found at the springs at Laugabol.

An abundant algal flora is supported in and around these

springs. Collections of Cyanophyceae, Chlorophyceae, and Diatoms were obtained, but these unfortunately have not yet been identified.

LIST OF PLANTS COLLECTED.

RANUNCULACEAE.

Caltha palustris L.	Vattarnes.
Ranunculus glacialis L.	Kaldbakur, Thingmannaheidi, Skalmardalsheidi.
,, *paucistamineus* Tausch. var. *eradicata* Laestad.	Brjanslaekur, Hagi.
,, *acer* L.	Vattarnes, Brjanslaekur, Hagi, Brekkunellir, Alftamyri.
,, *acer* var. *pumila* Whbg.	Kaldbakur.
,, *pygmaeus* Whbg.	Kaldbakur.
,, *repens* L.	Common especially near inhabited ground.
,, *reptans* L.	Brjanslaekur, Brekkunellir.
,, *hyperboreus* Rottb.	Kaldbakur, Vattarnes.
Thalictrum alpinum L.	Fossdalur, Kaldbakur.

PAPAVERACEAE.

Papaver radicatum Rottb.	Vattarnes, Kaldbakur, Hagi.
Papaver radicatum var. *albiflora* Stefan.	Hagi.

CRUCIFERAE.

Draba incana L.	Fossdalur.
,, *rupestris* (R. Br.) Lindbl.	Fossdalur, Brjanslaekur.
Cochlearia officinalis L.	Common near the sea.
Capsella bursa pastoris (L.) Medicus.	Alftamyri.
Cakile maritima (L.) Scop. var. *latifolia* Desf.	Brekkunellir.
Cardamine pratensis L.	Vattarnes, Fossdalur.
Arabis petraea (L.) Lam.	Fossdalur, Thingmannaheidi.
,, *alpina* L.	Fossdalur, Brjanslaekur.
Erysimum hieracifolium L.	Vogar.

VIOLACEAE.

Viola tricolor L.	Vattarnes.
,, *palustris* L.	Vattarnes, Brjanslaekur, Fossdalur.
,, *canina* L. var. *montana* L.	Vattarnes.

CARYOPHYLLACEAE.

Silene maritima With.	Vattarnes, Thingmannaheidi, Fossdalur, Kaldbakur, Hagi, Brjanslaekur.
,, *acaulis* L.	Vattarnes, Kaldbakur, Fossdalur.
Viscaria alpina (L.) Don.	Vattarnes, Fossdalur, Kaldbakur.

CARYOPHYLLACEAE—*continued.*

Cerastium trigynum Vill.	Vattarnes, Fossdalur, Brjanslaekur.
,, *alpinum* L.	Vattarfjall, Thingmannaheidi, Kaldbakur, Fossheidi, Brjanslaekur.
Stellaria media (L.) Vill.	Brjanslaekur.
,, *crassifolia* Ehrh.	Brjanslaekur, Brekkunellir.
Honckenya peploides (L.) Ehrh.	Brjanslaekur, Hagi, Brekkunellir.
Arenaria norvegica Gunn.	Brjanslaekur.
Sagina nodosa (L.) Fenzl.	Brekkunellir, Laugabol.
,, *subulata* (Sro.) Torr. et Gray.	Axlarsel.
,, *procumbens* L.	Vattarnes, Brjanslaekur, Hagi.
Spergula arvensis L.	Alftamyri.

PORTULACEAE.

Montia lamprosperma Cham.	Vattarnes, Brjanslaekur, Fossa, Alftamyri, Fossdalur, Kaldbakur.

GERANIACEAE.

Geranium sylvaticum L.	Vattarnes.

EMPETRACEAE.

Empetrum nigrum L.	Vattarnes, Thingmannaheidi, Fossheidi, Kaldbakur.

LEGUMINOSAE.

Vicia cracca L.	Laugabol.

ROSACEAE.

Potentilla anserina L.	Vattarnes, Hagi, Brjanslaekur, Alftamyri.
,, *palustris* (L.) Scop.	Fossdalur, Hagi, Vogar, Brjanslaekur.
,, *alpestris*, Hall fil.	Vattarnes.
Geum rivale L.	Vattarnes.
Dryas octopetala L.	Vattarnes, Vattarfjall, Thingmannaheidi, Fossheidi, Kaldbakur.
Rubus saxatilis L.	Vattarnes, Fossdalur.
Alchemilla minor Huds.	Brjanslaekur.
,, *alpina* L.	Vattarnes, Fossdalur, Vattarfjall, Thingmannaheidi, Fossheidi, Kaldbakur.
Sibbaldia procumbens L.	Vattarnes.

SAXIFRAGACEAE.

Saxifraga hirculus L.	Vattarfjall.
,, *oppositifolia* L.	Kikafell, Kaldbakur.
,, *nivalis* L.	Brekkunellir, Kaldbakur, Brjanslaekur.
,, *stellaris* L.	Vattarnes, Fossdalur, Kaldbakur.
,, *hypnoides* L.	Fossdalur, Kaldbakur.

SAXIFRAGACEAE—*continued.*

Saxifraga hypnoides L. subsp. *boreali-atlantica* Engl. et Irmsch.	Fossdalur, Kaldbakur.
Saxifraga cernua L.	Vattarnes, Kaldbakur.
,, *rivularis* L.	Kaldbakur, Vattarnes, Brjanslaekur.
,, *groenlandica* L.	Brjanslaekur.
Parnassia palustris L.	Brjanslaekur, Hagi.

CRASSULACEAE.

Sedum villosum L.	Hagi, Kaldbakur, Vattarnes, Brekkunellir.
,, *acre* L.	Brekkunellir, Brjanslaekur (sand-dune).

DROSERACEAE.

Drosera rotundifolia L.	Brjanslaekur.

HALORAGEAE.

Hippuris vulgaris L	Brjanslaekur.

ONAGRACEAE.

Chamaenerium latifolium (L.) Spach.	Brjanslaekur.
Epilobium alsinifolium Vill.	Fossdalur, Vogar, Skalmarnesmulafjale.
,, *anagallidifolium* Lam.	Vattarnes, Brjanslaekur.
,, *palustre* L.	Reykjanes, Brjanslaekur, Hagi.

UMBELLIFERAE.

Carum carvi L.	Laugabol.
Archangelica officinalis Hoffm.	Engy Island.
Haloscias scoticum (L.) Fr.	Alftamyri.

CORNACEAE.

Cornus suecica L.	Vattarnes, by Fossa.

RUBIACEAE.

Galium verum L	Vattarnes.

VALERIANACEAE.

Valeriana officinalis L.	Laugabol.

COMPOSITAE.

Erigeron borealis (Vierh.) Simm.	Vattarnes, Fossdalur, Kaldbakur.
Achellia millefolium L.	Alftamyri, Laugabol.
Matricaria ambigua (Ledeb.) Kryl.	Foss.
Leontodon autumnalis L.	Laugabol.
Gnaphalium supinum L.	Vattarnes, Brjanslaekur.
,, *norvegicum* Gunn.	Vattarnes.
Hieracium sp.	

Ericaceae.

Cassiope hypnoides Dan.	Vattarfjall, Thingmannaheidi, Fossheidi.
Arctostaphylos uva ursi (L.) Spr.	Vattarnes, Thingmannaheidi, Fossdalur.
Pyrola minor L.	Kaldbakur, Vattarnes, Brjanslaekur.
Loiseleuria procumbens (L.) Desv.	Fossheidi.

Vacciniaceae.

Vaccinium myrtillus L.	Vattarnes, Fossdalur.
,, *uliginosum* L.	Vattarnes, Fossdalur.

Gentianaceae.

Gentiana campestris L. subsp. *islandica* Murb.	Fossdalur, Fossa, Kirkjubol, Alftamyri, Brjanslaekur, Vogar.
Gentiana tenella Rottb.	Hagi, Laugabolsdalur.
,, *nivalis* L.	Alftamyri, Brjanslaekur.
,, *aurea* L.	Brekkunellir.
Pleurogyne rotata (L.) Griseb.	Hagi.
Menyanthes trifoliata L.	Brjanslaekur.

Boraginaceae.

Mertensia maritima (L.) G. Don.	Fornsel, Foss, Hagi.
Myosotis arvensis (L.) Roth.	Vattarnes.
,, *micrantha* Pall.	Brjanslaekur, Hagi.
,, *versicolor* (Pers.) Sm.	Alftamyri, Brjanslaekur, Hagi, Vattarnes.

Plantaginaceae.

Plantago maritima L.	Brekkunellir, Laugabol.
,, *maritima* L. f. *pygmaea*.	Laugabol.
,, *major* L.	Laugabol.
,, *major* L. f. *pygmaea*.	Laugabol.

Scrophulariaceae.

Rhinanthus minor Ehrh.	Brjanslaekur, Hagi, Alftamyri, Vattarnes, Laugabol.
Bartsia alpina L.	Vattarnes, Alftamyri.
Veronica alpina L.	Vattarnes, Fossdalur, Kaldbakur.
,, *fruticans* Jacq.	Fossdalur.
,, *officinalis* L.	Fossa.
,, *serpyllifolia* L.	Vattarnes.

Labiatae.

Thymus serpyllum L. var. *prostrata* Hornem.	Fossdalur, Kaldbakur.

Lentibulariaceae.

Pinguicula vulgaris L.	Vattarnes, Fossdalur.

PRIMULACEAE.

Glaux maritima L.	Brekkunellir.

PLUMBAGINACEAE.

Armeria vulgaris Willd.	Vattarnes, Thingmannaheidi, Brjanslaekur, Fossheidi, Fossdalur.

CHENOPODIACEAE.

Atriplex patulum L.	Brjanslaekur.

POLYGONACEAE.

Polygonum aviculare L.	Vattarnes, Hagi, Alftamyri, Brjanslaekur.
,, *persicaria* L.	Reykjanes, Isafjordur.
,, *viviparum* L.	Vattarnes, Fossdalur, Kaldbakur.
Koenigia islandica L.	Brjanslaekur, Fossdalur, Vattarnes.
Rumex acetosa L.	Vattarnes, Fossdalur.
,, *acetosella* L.	Fossdalur.
,, *domesticus* Hartm.	Brjanslaekur.
Oxyria digyna (L.) Hill.	Fossdalur, Vattarnes.

SALICINEAE.

Salix lanata L.	Vattarnes, Fossdalur, Brjanslaekur.
,, *glauca* L.	Fossdalur.
,, *herbacea* L.	Vattarnes.

BETULACEAE.

Betula pubescens Ehrh.	Vattarnes, Fossa, Fossdalur.
,, *nana* L.	Vattarnes, Fossdalur.

CONIFERAE.

Juniperus communis L.	Vattarnes, Fossdalur.

ORCHIDACEAE.

Corallorhiza trifida Chatelain.	Vattarnes.
Habenaria hyperborea (L.) R. Br.	Vattarnes.
,, *viridis* (L.) R. Br.	Vattarnes, Fossdalur.
,, *albida* (L.) R. Br.	Vogar, Isafjordur.
Orchis maculatus L.	Vattarnes, by Fossa.

LILIACEAE.

Tofieldia palustris Hudd.	Vattarnes, Fossdalur.

JUNCACEAE.

Juncus triglumis L.	Vattarnes.
,, *alpinus* Vill.	Brjanslaekur.
,, *balticus* Dethard.	Brjanslaekur.
,, *lamprocarpus* Ehrh.	Laugabol.
,, *castaneus* L.	Hagi.

JUNCACEAE—*continued.*

Juncus bufonius L.	Laugabol.
Luzula arcuata (Whlbg.) Sw.	Vattarnes.
,, *spicata* DC.	Brjanslaekur, Isle of Engy.
,, *multiflora* Leg.	Brjanslaekur.

TYPHACEAE.

Sparganium hyperboreum Laest.	Brjanslaekur.

NAIADACEAE.

Potamogeton filiformis Pers.	Reykjanes, Isafjordur.
Triglochin palustris L.	Brekkunellir, Fossdalur.

CYPERACEAE.

Eriophorum polystachyum L.	Vattarnes, Fossdalur, Skalmarnesmulafjall.
,, *Scheuchzeri* Hoppe.	Kletshals.
Scirpus palustris L.	Brjanslaekur.
Carex rariflora (Whbg.) Sm.	Brekkunellir.
,, *Goodenoughii* Gay.	Brekkunellir.
,, *dioeca* L.	Brjanslaekur.
,, *pulicaris* L.	Brjanslaekur.

GRAMINEAE.

Deschampsia caespitosa (L.) Beauv.	Vogar, Isafjordur.
Poa pratensis L.	Vattarnes, Brjanslaekur.
Phleum alpinum L.	Vattarnes, Brjanslaekur.
Poa glauca Vahl.	Brekkunellir.
Agrostis stolonifera L.	Brekkunellir.

FILICALES.

Dryopteris phegopteris (L.) C. Chr.	Vattarnes, Brjanslaekur.
,, *filix-mas* (L.) Schott.	Vattarnes.
Botrychium lunaria (L.) Sw.	Vattarnes, Fossdalur, Brjanslaekur, Hagi.
Polystichum lonchitis (L.) Roth.	Vattarnes.
Athyrium alpestre (Hoppe) Ryland.	Vattarnes.
Cystopteris fragilis (L.) Bernh.	Vattarnes.

LYCOPODIACEAE.

Lycopodium selago L.	Vattarnes.
,, *alpinum* L.	
Selaginella selaginoides (L.) LK.	Vattarnes, Fossdalur.

EQUISETACEAE.

Equisetum variegatum Schleich.	Brjanslaekur.
,, *arvense* L.	Kjalkafjardarar.

Fomes fomentarius (Linn.) Gill. [Ungulina fomentaria (Linn.) Pat.] on Birch in Scotland. By J. A. Macdonald, B.Sc., Ph.D. (With Pls. XXIX–XXX.)

(Read 19th May 1938.)

Introduction.

There is a species of *Fomes* widespread on the trunks and branches of birch trees in the Highlands of Scotland (fig. 1). Numbers of fruit bodies of the fungus were collected by the writer from various localities, *e.g.* Pitlochry (Perthshire), Aviemore and the Great Glen (Inverness-shire), Contin (Ross-shire). Perfect specimens measured from 5×5–35×20 cm. They varied in colour from pale silvery grey to dull or shining black on the upper surface and from whitish grey to reddish brown on the lower surface. Some were applanate and others hoof-shaped. The lower surface was frequently surrounded by a protruding, sterile rim. Usually they were produced singly, but occasionally groups of two or three emerged from the bark at or near the same point (fig. 2). At an early stage the developing fruit body was rounded in outline. Young fructifications were sometimes quite pliable and it was possible to imagine that the softer, inner parts might be used in the production of tinder. Characteristically, however, they were hard.

Species of Fomes Recorded on Birch in Britain.

Certain species of *Fomes* have been recorded on birch in Britain, and apparently more specifically in Scotland. These are *F. applanatus* (Pers.) Wallr., *F. fomentarius* (Linn.) Gill., *F. igniarius* (Linn.) Gill. and the doubtful *F.* (*Polyporus*) *nigricans* of Fries (1821). In modern classification the first three are regarded as belonging to distinct genera, while the position with regard to the last named is obscure. On a perusal of the existing literature it becomes clear that confusion has existed and still does exist in the minds of many botanists as to the correct identification of these species. In many of the earlier accounts of *F. igniarius* its qualities

as tinder, styptic, etc., are set forth [Lightfoot (1777), Relhan (1785)], and Gleditch is quoted on the question of its suitability for the manufacture of garments "like soft leather." These statements probably should refer to *F. fomentarius* with its softer texture and not to *F. igniarius*, which is usually much harder. Lightfoot (1777) states of *F. igniarius*: "It varies greatly in colour, thickness, and degree of hardness; whence some authors have made many species, but Linnæus comprehends them all under one." From this statement, taken in conjunction with the rest of his description, it appears very probable that Lightfoot was including both *F. igniarius* and *F. fomentarius* under the same name. The idea that there was a marked distinction between these two species, based on the hardness of the texture of the fruit body, was recognised by the time of Withering (1801) and Hooker (1821). The latter quotes Beauvois's statement that "amadou" is formed from the fructifications of *Boletus fomentarius* and "not our *Boletus igniarius*." From this time onwards the consistency of the fruit body is made great use of in separating the different species. Nevertheless these old records have been freely drawn upon, and there can be little doubt that many later citations of host and locality for both of these species are based on earlier doubtful work.

Another source of error is the confusion of *Fomes fomentarius* and *F. applanatus*. Thus Berkley (1860) states in his description of *F. fomentarius* "spores dark"—a character of *F. applanatus*. Probably arising out of these earlier mistakes, *F. fomentarius* is freely recorded on beech, oak, etc., in this country, even in the current literature [Rea (1922), Brooks (1928)]. Lloyd (1915), dealing with *F. fomentarius*, mentions a large, ungulate type of fructification with soft, punky texture occurring on beech in France, and a smaller, harder type of fructification occurring on birch in northern Europe. This is borne out by Miss Wakefield of Kew who, in the course of correspondence with the present writer, stated that "*F. fomentarius* does not occur in this country except in the Highlands"—and again that "As far as I know it never grows on beech in this country, and we have only the birch form."

Fries (1821) described *Polyporus fomentarius*, *P. nigricans* and *P. igniarius*. The second species appeared from his

description to come near to *P. fomentarius*, being distinguished mainly by a harder consistency and by its habitat "ad truncos Betulae, nec alibi." It is clear that Fries realised there was some difficulty in distinguishing between his three species from his statement in the Elenchus Fungorum (1828) under *P. igniarius*—"Specemina, quae ut normalia servo, a *P. fomentario* et *nigricante* luculentur differunt, sed formae exoletae et resupinatae non sine difficultatae dignoscuntur. Plures auctores status exoletos et induratos *P. fomentarii* et *P. nigricantis* pro hoc fungo habent." Berkley (1860) mentioned *P. nigricans* on birch in Scotland, on the authority of Klotsch. No doubt swayed by his original misconception of *fomentarius* (see p. 397), he described *nigricans* as "a neater and more shining plant than the following" (*igniarius*). Stevenson (1879) recorded both *P. fomentarius* and *P. nigricans* on birch in Scotland. The tendency in more modern work has been to reduce the species *nigricans* to varietal importance. But the original idea of Fries that it was allied with *fomentarius* and the tendency accepted by Berkley towards regarding it as coming closer to *igniarius* have led to the formation of two varieties. One, *nigrescens*, is regarded as a variety of *F. fomentarius*, while the other, *nigricans*, is placed under *F. igniarius*. In both cases the variety is supposed to include dark, shining fructifications. As a result of this, in Britain alone, we are faced with records on birch of *F. fomentarius*, *F. fomentarius* var. *nigrescens* and *F. igniarius* var. *nigricans*—Rea (1922).

With regard to the records of *Fomes igniarius* on birch in Scotland, it must be stated that so far the writer has not found any specimens. If it does occur it must be rather rare. Miss Wakefield informed the writer that she had not seen it from birch but only from willow, when the host was specified. It may be mentioned in passing that many records of *F. igniarius* include cherry and plum among its hosts. It seems exceedingly likely that these are misdeterminations of *F. pomaceus*. This, apparently, is the view taken by Lloyd (1915).

The Identity of the Scottish Specimens.

At a casual inspection it would be easy to put one or other of the Scottish specimens under any of the species or varieties

	Scottish Material.	*F. fomentarius* (*Ungulina fomentaria*).	*F. igniarius* (*Phellinus igniarius*).	*F. applanatus* (*Ganoderma applanatum*).
Fruit Body.				
Size	5 × 5–35 × 20 cm.	10–40 × 10–20 cm. (Bo.) 5–13 cm. (Sp.).	10–20 cm (Bo.) 3–10 × 5–20 × 2–10 cm. (Ov.).	10–40 cm. (Bo.). 7–26 cm. (Sp.).
Colour . . .	Silver-grey to black.	Grey above, brown-grey below. Projecting rim (Sp.).	Grey-black to black (Ov.).	Grey-brown above, white below, edge thin (Sp.).
Consistency . .	Medium to very hard.	Soft, punky [Beech] (Ll.). Harder [Birch] (Ll.)	Very hard (Br.).	Firm (Br.).
Setae . . .	None	None (Bo.)	Present (Ve.).	None (Bo.).
Pores . . .	2–3 per mm.	3 per mm. (Bo.)	3–5 per mm. (Ve.) 4–5 per mm (Bo.)	4 per mm.
Spores:				
Size	15–20 × 6–7 μ.	16 × 5 μ (Ll.) 16–18 × 5 μ (Br.) 14–18–22 × 5–7 μ (Bo.).	5–6 μ (Ll.). 5–6 × 4–5 μ (Bo.). 6–7 μ (Mu.). 5–7 μ (Br.)	9–13 × 6–8 μ (Br.). 8–12 × 5–8 μ (Bo.). 7–9 × 5–6 μ (Wh.).
Shape . . .	Oblong.	Oblong (Bo.). Globose (Mu.).	Globose (Mu.). Sub-globose (Bo.).	Double wall blunt apex (Bo.).
Colour . . .	Hyaline.	Hyaline (Br.) Very light brown (Mu.)[1].	Hyaline (Bo.).	Reddish brown (Wh.). Clear brown (Bo.).
Time of discharge .	April–June.	April–May [2 weeks] (Fa.)	August [2 weeks] (Ve.).	May – October or November (Wh.).
Mycelium:				
Colour of young growth	White.	White.	White	White.
Type . . .	Woolly.	Woolly.	Cobwebby.	Silky.
Colour of old growth .	Pink-brown through cinnamon to chestnut	Pink-brown through cinnamon to red chestnut.	Yellow- to mummy-brown (Ve.).	Olive-yellow to purple-brown.
Type . . .	Mat usually tough and leathery	Mat usually tough and leathery	Aerial growth softer, less matted	Mat tough, skin-like, wrinkling.
Clamp connections	Yes	Yes (Ru.) (Fr.).	No (Ve.) (Fr.).	Yes.
Growth rate. Slants covered at 22° C.	3 weeks up.	3 weeks up.	2½–4 weeks	2–3 weeks.
Oxid. rings . .	Marked.	Marked	Marked	None or faint.
Zone lines .	Black.	Black (Hu.)	Thin black (Hu.)	Brown (Wh.) (Hu.).
Wood rot . . .	Yellow-white	Mottled yellow-white (Hu.).	Yellow-white heart rot (Sp.)	Mottled white heart rot (Wh.).

mentioned in the second paragraph on page 397. But enough has been said to draw attention to the pitfalls which lie in the way of a casual determination based on an examination of the macroscopic features of the fructification, even when it is coupled with a knowledge of the host plant. The use of certain microscopic features of the fruit body and of the vegetative mycelium makes the distinction relatively easy. The most interesting of these, in the present connection, have been collected in the table on p. 399, largely from the work of the following authors: Bourdot and Galzin (1925), Brooks (1928), Faull (1937), Fritz (1923), Hubert (1924 and 1931), Lloyd (1915), Murrill (1908), Overholts (1915), Rumbold (1908), Spaulding (1937 *a* and *b*), Verrall (1936), and White (1920).

The Scottish fungus seems to agree fairly closely with *Fomes fomentarius* and may be regarded safely as belonging to this species. It differs from *F. igniarius* most strikingly in the presence of clamp connections on the hyphae, in the larger spore size and in the absence of setae in the fructification. The colour and character of the spores and the general appearance of the vegetative mycelium are markedly different from those of *F. applanatus*. The general appearance of the mycelia in culture is also a valuable guide (figs. 3–6).

VARIATION IN FOMES FOMENTARIUS.

It has been mentioned that certain of the Scottish specimens are black and shiny. The tendency would be to regard these as belonging to the variety *nigrescens*. However, this dark form occurs in close proximity to, and even on the same birch trunk with, lighter, more silvery-grey specimens which would naturally fall under *F. fomentarius* proper. The latter are indistinguishable from small fruit bodies of Canadian origin formed on beech. It is easy to arrange a series of fructifications passing gradually from the typical lighter forms to the darkest specimens, and almost impossible to draw any satisfactory line of separation. It is clear, therefore, that it is not possible to distinguish absolutely, on the grounds of gross sporophore characters, either the forms of *F. fomentarius* on birch from those on beech or a form *nigrescens* within the types occurring on birch. In

order to ascertain whether or not such distinctions hold good when based on gross or microscopic features of the vegetative mycelium, cultures were obtained from dark and light fruit bodies and from infected birch wood. These were grown in series with isolations of *F. fomentarius* and *F. fomentarius* var. *nigrescens* from birch and *F. fomentarius* from beech obtained from Ottawa, Baarn and Princes Risborough.

Verrall (1936), from a detailed study of *Fomes igniarius*, has stated that there are three forms within this species, namely, one on poplar, one on birch and one on miscellaneous hosts. He pointed out that fruit bodies identified for him by a number of authorities as *F. igniarius* var. *nigricans* might come into any one of his three groups. These groups were founded both on the characters of the fructification and of the mycelium in culture. Verrall makes it clear that, while in his opinion there are host-varieties within the group comprising *F. igniarius*, there can be little justification for continuing to use the varietal name *nigricans*.

Rumbold (1908) and Fritz (1923) have described the mycelium of *Fomes fomentarius* without recording any variation of the type mentioned in the preceding paragraph.

The cultures were grown on potato-dextrose agar slopes as described by Fritz (1923). Four tubes were inoculated with mycelium from each culture and were incubated at 22° C. They were examined at intervals over a period of one month. A list of the cultures follows, together with other relevant data (on next page).

It was found that there was very considerable variation in the rate of growth, rate of development of colour and intensity of colour in the different mycelia. Apart from the marked variation in luxuriance, no character was discovered which fell outside the range of those mentioned by Fritz (1923) for *Fomes fomentarius*. When the cultures were arranged as far as possible in series according to growth rate, or quality or degree of pigmentation of the mycelium, it was found to be impossible to separate them into distinct groups. In addition, isolations from any one host and from the *nigrescens* type of fructification showed as wide variation among themselves as was observable throughout the whole group (figs. 6–14). It is particularly interesting to note the difference between the cultures in figs. 9 and 10. These are

Culture. Received from	Isolated by	Locality.	Host.	Material for Inoculum.
1. F. Scot.	J. A. M. (1933)	Contin	Birch	Wood
2. F. Scot.	J. A. M. (1936)	Pitlochry	Birch	Wood
3. F. Scot.	Fort (1937)	Pitlochry	Birch	Fructification
4. F. Scot.	J. A. M. (1937)	Aviemore	Birch	Fructification
5. var. *nigrescens* Baarn	Cartwright	Aviemore	Birch	Fructification
6. No. 634F, Ottawa	—— (1926)	Quebec	Birch	Fructification
7. No. 2252F, Ottawa	Macrae (1932)	Manitoba	Birch	Fructification
8. No. 2160F, Ottawa	Overholts (1932)	——	Birch?	Fructification
9. No. 1307F, Ottawa	Mounce (1930)	Ottawa	Beech	Fructification
10. No. 79c, Princes Risborough	Mounce (1930)	Ottawa	Beech	Fructification
11. No. 79*e*, Princes Risborough	Findlay (1930)	Austria	Beech	Fructification

two transfers of the same isolation made by Miss Mounce from beech, but were obtained from Ottawa and Princes Risborough respectively. The eleven mycelia were grown on films of filtered malt and prune agar on glass slides [Sass (1929)] and were examined microscopically. No constant differences were found between isolations from beech and birch or between mycelia of the variety *nigrescens* and the typical *fomentarius*. All the more luxuriant mycelia are found among the more recent isolations. As was to be expected, it seemed that the mycelia declined in vigour when kept in culture for a number of years. The mat was closer and more granular. In addition, they tended to develop their brown colouring earlier. There was no difference

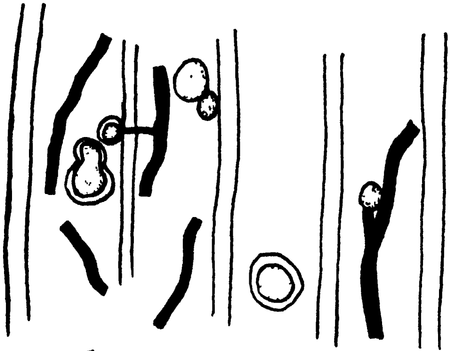
between isolations made from fructifications and those from wood.

All isolations gave distinct oxidation rings with tannic acid when tested by Bavendamm's method (1928 and 1936). The haloes varied little in intensity. There was no difference between those formed by mycelia isolated from different hosts or between those formed by mycelia of *F. fomentarius* proper and the *nigrescens* variety.

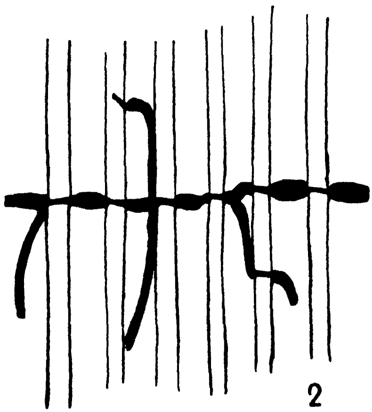
CHARACTERS OF THE SCOTTISH MYCELIA.

(*a*) Growth on wood. The type of hyphal growth on naturally and artificially infected wood was studied. Eleven different types of wood, on which *Fomes fomentarius* and *F. nigricans* have been recorded in this country and in America, were inoculated with the mycelium from the Scottish isolations. These were compared with natural infections. The fungus grew on all the wood blocks experimented with—alder, beech, birch, elm, hornbeam, horse chestnut, lime, maple, oak, poplar and willow. There was marked variation in the vigour of the growth produced to begin with. At the end of two months, growth on horse chestnut was most advanced, with birch next. The others, arranged in order of the luxuriance of the growth produced, were elm, hornbeam, oak, lime, poplar, beech, maple, alder and willow. Hubert (1931) has described the rot produced by *F. fomentarius* and the appearance of the hyphae in the host tissues. Liese (1928) regarded *F. fomentarius* as belonging to the "destruction" type of wood-attacking fungi, *i.e.* attacking cellulose. Campbell (1932) has shown that *F. fomentarius* attacks both cellulose and lignin in the early stages of its wood-rotting activities. The type of rot produced in culture, on all the woods experimented with, corresponded with that found in nature. After six months the wood had become quite soft and easily broken down between the finger-nails. In the case of birch the wood is yellow-white in colour. In natural infections pronounced sheets of mycelium develop in the position of the wood cambium and, to a lesser extent, between the annual rings of the wood. The rotted wood may be mottled in appearance, due to these aggregations of hyphae. Sections of infected birch wood showed the hyphae

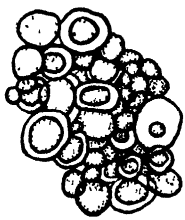
to be abundant in all the wood and living bark tissues. They were particularly well seen in radial longitudinal sections stained with safranin and picro-aniline blue according to Cartwright's (1929) schedule. They were most numerous in the medullary rays. Intercalary, thick-walled, yellow chlamy-



1



2



3

dospores were observed in some cases, though these were never numerous (text-fig. 1). Mounce (1929) has figured similar structures for *Fomes pinicola*. In general the hyaline hyphae are not markedly constricted as they pass through the hour-glass-shaped boreholes. Old hyphae, which are unusually broad and which have developed a yellow colour, are constricted in a pronounced manner (text-fig. 2).

(*b*) Zone Lines.—These were found in naturally and artificially infected birch, on all the types of wood artificially

infected and on many of the agar cultures. The black lines were made up of rows of swollen, "bladder" hyphae [Campbell and Munson (1936)], with the typically thickened, dark brown, apical walls [Macdonald (1937)]. On agar culture the appearance presented was sometimes rather unusual in the case of the hyphae composing broad lines. When seen in surface view they suggested collections of thick-walled, brown spores densely packed together (text-fig. 3). On wood blocks these zone lines usually mark the point of contact of the mycelium with the glass of the boiling tube containing the culture. On agar they may form in this position also, but just as frequently they appear on and in the medium and mark the limit of activity of the mycelium in one growth period. Renewed activity of the mycelium may or may not follow the resting phase. If it does the black line is merely overgrown by the activity of hyphae inside the fungus colony. It does not seem that the terminal, thick-walled cells of the zone line renew active growth.

(*c*) Clamp Connections.—The appearance of the hyphae has been described by Fritz (1923). Clamp connections are regularly present in the vegetative hyphae. The formation of these was studied in young, actively growing mycelia by means of the agar film technique. The nuclei are regularly paired and appear to use the clamp connections in what may be termed the usual way, *i.e.* types 1 and 2 of Noble (1937). In one or two cases apical cells were noted in which only a single nucleus could be seen. It was always found that under these circumstances active growth had been transferred to a side branch in which the normal paired nuclei were present in each cell.

Discussion.

It is clear, from a study of the existing literature, that confusion has always existed as to the correct identification of *Fomes fomentarius* (Linn.) Gill., *F. igniarius* (Linn.) Gill. and *F.* (*Polyporus*) *nigricans* Fr. It seems to the writer that the reason for this confusion is that there are, within the species *F. fomentarius*, two superficially distinct types of fruit body, which mark the extremes of the variation within this species and are to be found at different latitudes. In the south, in France, there is found on beech a rapid-growing, soft form.

In northern Europe, including the Highlands of Scotland, there occurs a slower growing, harder, and often considerably darker type on birch. It is highly probable that at the time of his original determination of *F. nigricans* Fries regarded the southern form of *F. fomentarius* as typical of that species and gave the new name to the northern European type. He stressed the fact that it was intermediate in qualities between *F. fomentarius* and the harder *F. igniarius*. Some of his later determinations are, in fact, *F. igniarius* [Lloyd (1915)]. If the foregoing is a true interpretation of the facts it becomes clear that it is unsound to persist in the use of the varietal name *nigricans* for a form of *F. igniarius*. Verrall (1936) has shown that this variety of the field mycologists is inconstant in its characters and that the retention of the name cannot be justified botanically. In the present study the writer has shown that this is true also of the variety *nigrescens* of *F. fomentarius*. It might be argued, in the latter case, that it is worth while retaining a varietal name for the small, hard type of fructification irrespective of its colour. However, no constant characters can be found to separate either the two fructification types or their associated mycelia. Verrall (1936) recognised races in *F. igniarius* associated with host types or groups. No such association seems to exist for beech or birch in the case of *F. fomentarius*.

The experimental evidence brought forward in the present work proves that distinct varieties do not occur within the species *Fomes fomentarius*. It follows, therefore, that the names *F. nigricans* and *F. fomentarius* var. *nigrescens* should be regarded merely as synonyms of *F. fomentarius*.

SUMMARY.

1. The use of the various names applied to species and varieties of *Fomes* on birch is discussed.

2. Fruit bodies of a type of *Fomes* prevalent on birch in the Highlands of Scotland were identified as *F. fomentarius*, some being of the dark, shining type usually called variety *nigrescens*. When examined microscopically the latter were found to be similar to the typical fructifications of the species.

3. Mycelia of *F. fomentarius* from beech and birch and of *F. fomentarius* var. *nigrescens* from birch were obtained from a number of workers and compared with the Scottish isolations.

4. They were found to form one fairly wide group. It was not possible to distinguish forms on beech from those on birch, either macroscopically or microscopically, nor did the mycelia of *F. fomentarius* var. *nigrescens* differ from those of the forms normally occurring on either host.

5. The type of wood rot, zone lines and certain other mycelial features are described for the Scottish material.

6. It is shown that *Fomes nigricans* and *F. fomentarius* var. *nigrescens* are mere synonyms of *F. fomentarius*.

The writer is indebted, for helpful information and for the identification of specimens, particularly to Miss Wakefield of Kew, Mr. Findlay of the Forest Products Research Laboratory, Miss Mounce of the Dominion Experimental Farm, Ottawa, Mr. Perley Spaulding of the U.S. Department of Agriculture and Professor Westerdjick of Baarn.

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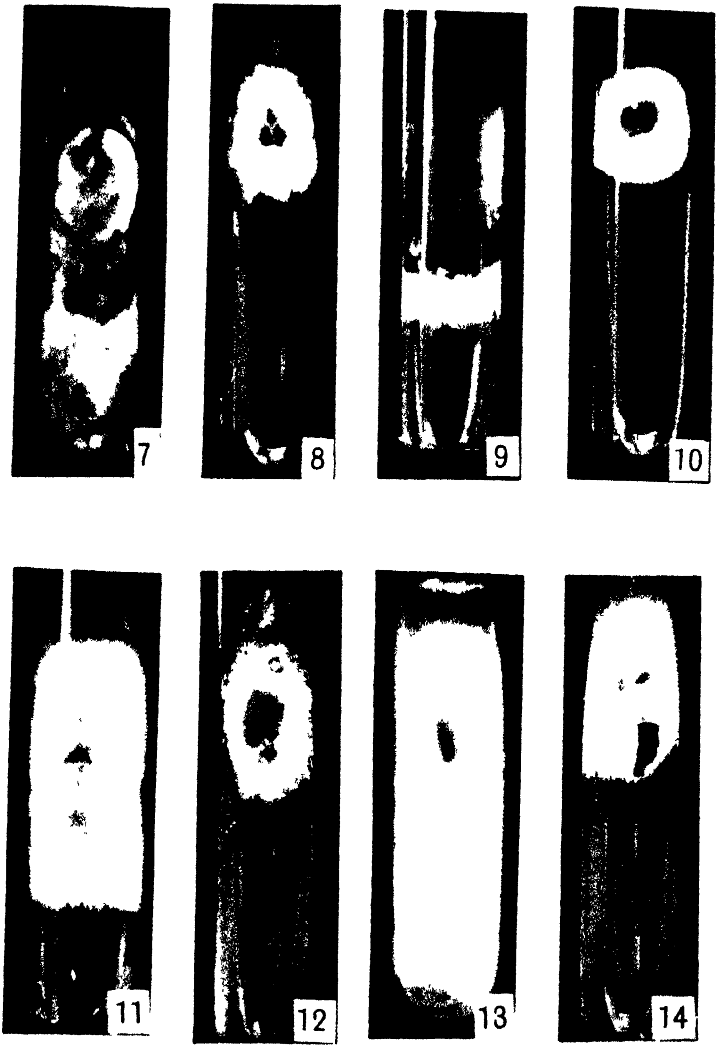
EXPLANATION OF PLATES XXIX AND XXX.

Fig. 1. *Fomes fomentarius* on birch trunk. Pitlochry.
Fig. 2. *F. fomentarius* group of fructifications from birch.
Figs. 3–14. Cultures on malt agar. Cultures in figs. 3–6 one month old: in figs. 7–14 three weeks old.
Fig. 3. *F. fomentarius* from pale fructification (3). Birch.
Fig. 4. *F. igniarius*.
Fig. 5. *F. applanatus*. Birch.
Fig. 6. *F. fomentarius* from black fructification (4). Birch.
Fig. 7. *F. fomentarius* var. *nigrescens* (5). Birch.
Fig. 8. *F. fomentarius* from wood (1). Birch.
Fig. 9. *F. fomentarius* from fructification (9). Beech.
Fig. 10. *F. fomentarius* from fructification (10). Beech.
Fig. 11. *F. fomentarius* from fructification (11). Beech.
Fig. 12. *F. fomentarius* from fructification (6). Birch.
Fig. 13. *F. fomentarius* from fructification (7). Birch.
Fig. 14. *F. fomentarius* from fructification (8). Birch ?.

(The numbers in brackets refer to culture numbers in table on p. 402.)

J. A. Macdonald.



J. A. Macdonald.

The Development of Elymus arenarius Linn. on the West Sands, St. Andrews. By R. J. D. Graham, M.A., D.Sc. (With Pl. XXXI.)

(Read 21st April 1938.)

To Charles Howie, elected an Associate of the Botanical Society of Edinburgh in 1850, is attributed the credit of having introduced the Lyme Grass *Elymus arenarius* to the links at St. Andrews (1). From the records of the Town Council it would appear that this took place about the year 1847. Planted near the High Hole on the Old Course to prevent erosion of the green there, the grass has spread both to the right, round the Outhead until it has reached the Swilcan near St. Andrews—a distance of 2 miles; and also to the left, along the banks of the Eden, where it is now found on the masonry sea-wall half-way to Guardbridge—a distance of 1½ mile. The greatest depth of ground reclaimed by the introduction of Lyme Grass is on the rifle-range, where as far back as 1908 the old shore line was stated to be 160 yards inland. To-day the depth of reclaimed ground is 375 yards, a gain of over 200 yards in thirty years. Thanks to Dr. John Wilson, who was the first Lecturer in Botany in the University of St. Andrews and was for many years an active Fellow of the Botanical Society, it is possible to record pictorially the changes that have taken place in these thirty years. Dr. Wilson's Trustees made over to the Botany Department a collection of photographs and lantern-slides. Amongst the latter is a picture of the rifle-range taken in August 1908 (fig. 1). In the intervening thirty years this area of rough bents has been converted into the Jubilee Golf Course. A photograph of this same region taken at the present date gives a comparison with the condition thirty years ago (fig. 2).

Warming (2) was the first to give a concise account of the successions on the sand-dunes and to recognise the two principal associations—*consocies*—Elymetum and Psammetum. It was, however, in the reign of William III. that the

Scots Parliament passed a law for the preservation of these sand-binding grasses, though the British Parliament only extended the law to England in the reign of George II. (3).

In considering the reclamation work of Elymus at the West Sands, there are two aspects to be borne in mind. There is the lateral extension from the original situation covering a distance of some 3–4 miles, and there is the extension in depth outward toward the sea. Wilson (4) states that " nature has not been unassisted" and that the lateral extension is due in part to the planting of ears in the sand. The extension in depth towards the sea is, on the contrary, a natural process. The Elymus grains which ripen in the late summer are scattered towards the sea by the strong S.W. winds of autumn. In October of each year a green fringe of seedling Elymus is found spreading towards the sea. The fact that Elymus owes its extension in certain situations to the scattering of the grains appears not to be sufficiently recognised when Arber (5) and Ridley (6) mention only the dispersal of the plant by the drift of rhizome branches in the sea.

The whole reclamation of the shifting sand at the region of greatest gain is not solely the work of Elymus. On the seaward side of the farthest out clumps of Elymus is a more or less open association of *Agropyron junceum*. This is the only station for this grass on the West Sands, though it occurs on the East Sands.

SUMMARY.

The extension of *Elymus arenarius* chiefly by the distribution of its grains is described from St. Andrews.

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(4) WILSON, J. H.: *Op. cit.*, p. 61.
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Fig. 1 Rifle range, St Andrews, showing growth of *Elymus arenarius* in August 1908 Photograph from lantern-slide by J. H Wilson

Fig 2 - The Jubilee Golf Course, St. Andrews, in July 1938

R. J. D. Graham.

A Note on the Seismonic Irritability of Oxalis bupleurifolia A. St. Hil. By R. J. D. Graham, M.A., D.Sc. (With Pl. XXXII.)

(Read 16th June 1938.)

Not a little injustice is done to one member of the Oxalidaceae in the statement by Stiles (1) that "there are, however, a number of other species, particularly in the Leguminosae and Oxalidaceae, which show a definite response to shock stimulation, although not so noticeable a one as given by *Mimosa pudica*." Nor does the genus Oxalis find a place amongst the exceptions to the above general statement given on a later page (2). It is hoped to show that *Oxalis bupleurifolia* is as responsive to seismonic stimulation, possesses a quicker power of recovery after stimulation, is more amenable to cultivation, and is thus a more useful plant for experimental work in the ordinary class-room than its more famous and better known rival.

Oxalis bupleurifolia is a native of Brazil. As grown in pots in this country (fig. 1) the plant is a woody evergreen, branching freely from the base. The most characteristic feature of the plant is the laterally compressed phyllode, which is frequently used in many teaching centres to illustrate this modification of the petiole. The phyllode is normally set with the narrow edge toward the incident rays, but variations in the orientation towards light are of common occurrence. The glabrous phyllode attains a length up to 4–6 cm. and terminates in the usual trifoliate lamina characteristic of so many species of the genus. The leaflets, which with their petiolules are deciduous, vary in colour and size within wide limits, while the hairy petiolules of each leaflet are consistently about 1 mm. in length.

The plant grows well even in half shade at a temperature of 70° F., and is thus adapted to cultivation in the ordinary school-room. Growth is continuous throughout most of the year, and new flushes of growth can easily be induced, thus providing a supply of experimental material at all seasons.

A further recommendation is that the plant is easily propagated vegetatively by cuttings made from the current growth.

Material for experiments may be obtained from leaflets growing on the plant, by severing a branch with attached leaflets and placing the branch in a suitable container of water, or by severing individual leaves by cutting the phyllode and either floating the detached leaves on water or placing the cut end of the phyllode in water in a shallow dish. In certain experiments it was found that in a glass-house standing at 87° F. individual leaves could be severed, placed in water, and used for experimental work within 5 minutes of removing them from the plant. Those who have experimented with the material usually recommended in textbooks will appreciate this rapid recovery.

The stimulus may be applied in any of the recognised methods, contact with the hand or the point of a needle or badger's pencil. The leaflets also respond to flaming (3) with a lighted match or red-hot wire held below the leaflets at such a distance that the leaf-tissues are uninjured. It is of interest to note in this connection that contact stimulation is more effective when applied to the leaflet apex from below upwards rather than by touching from above in a downward direction.

The latent time for the seismonastic response is usually very short, being less than one second at temperatures above 70° F. The response to the stimulus is seen in a falling of the leaflet instead of the upward closing movement of the leaflet seen in Mimosa. Stimulation of the terminal leaflet under certain conditions is transmitted basipetally to the lateral leaflets, which also fall downwards. Severance of the phyllode also results in the fall of the leaflets, the stimulus passing acropetally. The period between cutting and the fall of the leaflets depends on a number of conditions. Under certain conditions the lateral leaflets responded within 30 seconds, the terminal falling 10 seconds later. Recovery after stimulation is amazingly rapid, and was fully accomplished in 3 minutes at 87° F. Cut leaves were thus available for experiment within 5 minutes of removal, provided they were carefully handled and were immediately placed in water of the same temperature as that of the house where the plant

was growing. The time of recovery was independent of the weight of the leaflet, as leaves turned with their ventral surface upward took the same time to recover as normally placed leaves. The time of recovery is longer on the application of a second stimulus to the same leaflet immediately after recovery. The latent time increased while the amplitude of the movement decreased with lowering temperature. At 60° F. the fall of the leaflets could clearly be demonstrated even on leaves of a plant carried from a glass-house to the class-room. Cut leaves floated on water with the end of the phyllode submerged responded to stimulation by movement of the phyllode through the water owing to the surface tension between the leaflets and the water.

The movements of the leaflets are brought about by changes in turgor principally in the ground-tissue cells of the petiolule, but certain cells of the epidermis are also involved. As already mentioned, the epidermal cells of the petiolule bear unicellular hairs. Many of the epidermal cells have deeply staining contents, as also have the cells of the ground tissue, particularly on the adaxial side (fig. 2). The contents of these cells are so sensitive and turgor changes occur so rapidly that it is extremely difficult to secure proper fixation of the material. Even transference from water to fixative yields preparations with many of the cells showing contracted contents. The vascular tissue is situated in a central position as a single tract. Many of the phloem elements, as well as several of the ray cells, also show deeply staining contents. The distribution of the "active" (4) cells differs from that of Mimosa, in which the "active" cells are situated on the lower (adaxial) side of the pulvinus. As a consequence of the turgor changes occurring all round the petiolule of Oxalis, the leaflets are limp after stimulation and move slightly under their own weight when the leaves are inverted. The leaves and leaflets of Mimosa do not move in this manner, as the turgor (5) of the cells of the upper half of the pulvinus is unaltered.

SUMMARY.

The use of the leaflets of *Oxalis bupleurifolia* for experiments on seismonic irritability is advocated in preference to Mimosa on the grounds that the leaves are as responsive and

recover more quickly after stimulation. A further advantage is that the plant is of easy cultivation.

The distribution of the active cells is described and compared with the distribution found in Mimosa.

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FIG 1.—Pot plant of *Oxalis bupleurifolia* showing habit, phyllodes, and leaflets.

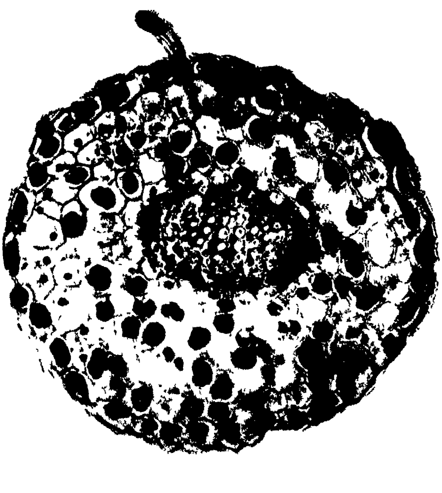


FIG. 2.—Photomicrograph of transverse section of petiolule to show distribution of "active" cells.

R. J. D. GRAHAM.

The Root System of Ranunculus monspeliacus.

By Ian B. Crockart, B.Sc.

(Read 16th June 1938.)

Introduction.

The perennating part of this plant consists of a portion of stem with an associated rosette of storage roots, surmounted by an apical bud, which is protected by a close matting of hairs and by the shrivelled bases of leaves. Underneath the storage roots is a scar representing the point of attachment of the now shrivelled stolon (fig. 1).

Growth starts by the development of an adventitious fibrous root system above the storage roots, followed by the production of a rosette of leaves.

After the formation of the fibrous roots, should the perennating portion lie deeply buried, adjustment in level takes place by the continuation of the stem to the surface of the soil, where the rosette of leaves develops (fig. 2). The erect stem portion, consisting of one or two internodes each about half an inch long, bears scale-leaves but usually no roots at the nodes.

The storage roots begin to form after the leaf blades have expanded. They are given off near the soil level, above the already well-developed fibrous roots, or occasionally among them. In the case of plants showing depth adjustment the adventitious roots at the base of the leaf rosette may all be storage roots, or there may be a preliminary formation of fibrous roots (fig. 2, *a*).

There is thus in the life-history a succession, both in time and orientation, from old storage roots to new fibrous roots to new storage roots (fig. 3). During the development of the new storage roots the old storage roots gradually shrivel.

In addition to roots, stolons develop. These arise from the axils of scale or ordinary leaves, and break their way through the leaf-bases to the exterior. They may arise among the old storage roots, among the fibrous roots, or among the new storage roots. They run horizontally and consist of elongated internodes from 1 to 5 inches in length; at the nodes they

bear encircling scale-leaves. After a growth in length varying from 1 to 5 inches, the stolon tip turns upward and develops

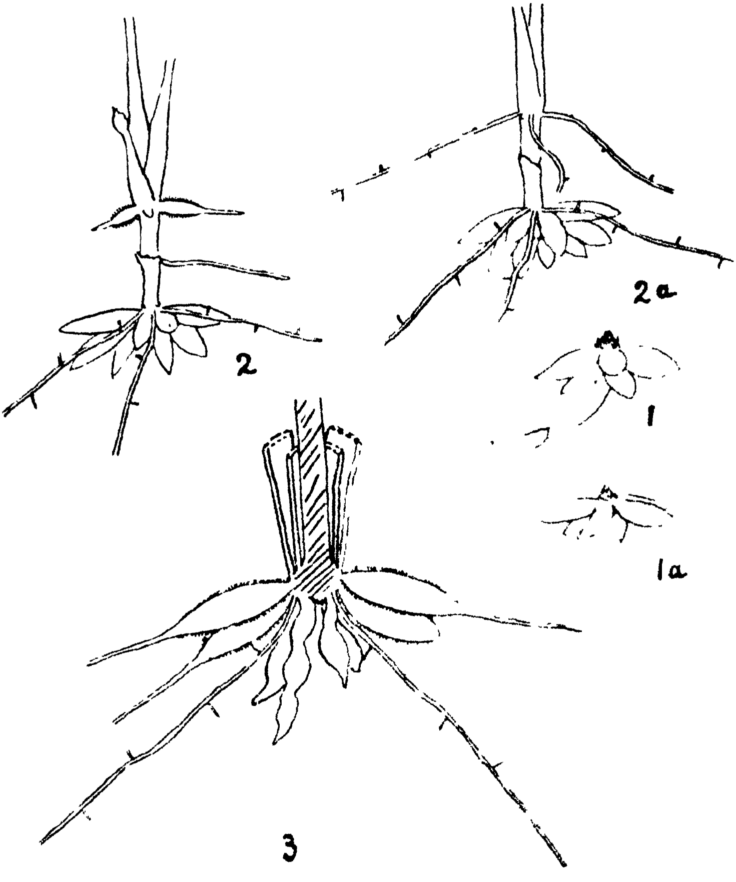


FIG. 1 shows the rosette of storage roots surmounted by the apical bud and attached to the end of the stolon. In 1a the stolon has decayed away.

FIGS. 2 and 2a.—In both depth adjustment is shown. 2 shows only storage-root formation at the leaf-bases. There is also the rather uncommon feature of root development at the intervening node. 2a shows fibrous root production at the leaf-bases.

FIG. 3.—A vertical section through the base of the plant showing the sequence in root development.

a few juvenile leaves immediately above the last scale-leaf. Roots first develop at the last scale-leaf node, later production taking place at one or more higher nodes (fig. 4). Generally

all these roots are of the storage variety, though the earlier ones may occasionally be fibrous.

Further development consists in the maturation of these new storage roots, both on the mother-plant and at the stolon tips, the development of the leaves, and the production of a flowering axis from the mother-plant.

At the close of the growing season the aerial portions, as well as the stolons, the fibrous roots, and the old storage roots, wither away, leaving the perennating portion of the mother-plant surrounded by detached daughter-rosettes. The survival of the plant which has given rise to the flowering axis is significant in view of the fact that, locally, no fertile seeds are produced, nor did the seeds obtained from British and Continental sources germinate.

The Development of the Roots.

As regards the fibrous root a considerable growth in length takes place before root-hairs are produced. After initiation, root-hair production takes place in the normal manner. Lateral roots are developed early and these are uniformly distributed along the main root.

A type of root intermediate in *form* between the normal fibrous root and the storage root is seen in those roots which show delayed production of lateral roots and a certain amount of swelling at the base, which, however, does not show the hairy covering characteristic of the storage root.

Right from the start the base of the storage root is thicker than that of the fibrous root. As in the fibrous root, the root tip becomes thinner as growth in length proceeds. Root-hairs are produced immediately, the base of the root being clothed in a thick piliferous layer. When a length varying from 1 cm. to 3 cm. is covered, hair production ceases. During the growth in length, varying degrees of swelling of the storage-root base take place, those roots which swell the earliest in development swelling the most. Thus the storage root consists of a proximate, swollen storage region with a marked piliferous layer, and an elongated distal, unthickened fibrous region. In the most advanced type this prolongation is short, being about 1 inch in length. This form of storage root approaches the type seen in *R. ficaria*, where the whole

root, except the root-cap, becomes modified for storage (1). Lateral roots, when present, are confined to the fibrous prolongation (fig. 5).

The Anatomy of the Roots.

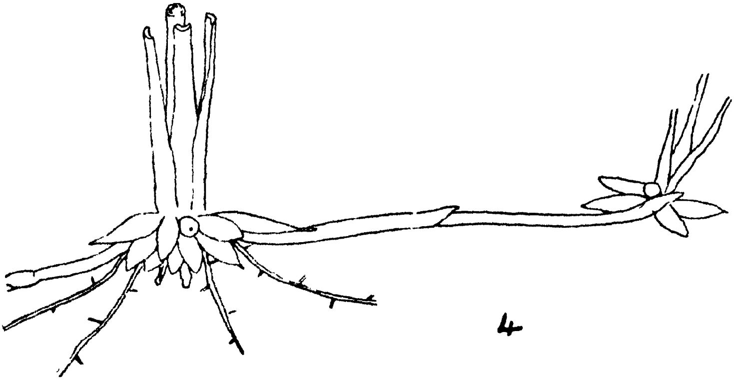
The cells of the limiting layer, of the exodermis and of the cortex are more elongated in the fibrous root than in the storage root.

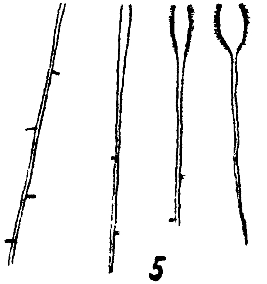
In the fibrous root suberisation of the exodermis begins just behind the root-hair region. In the storage root the exodermis is prominently suberised, the function of the piliferous layer being not absorptive, but to give the rosette of storage roots a firm position in the soil.

The cortex of the fibrous root is about 6 cells deep, reaching at the base 8 or 9 cells in depth, starch grains being absent from the cells. The cortex of intermediate root-bases is about 12 cells deep, while that of the storage root may vary from 10 to 15 cells in depth. These figures are not significant, but a transition is indicated. The fact that the cortical cells of the intermediate root-base do not contain starch grains separates off that type of root from thin storage roots.

The endodermis of the fibrous root is markedly thickened and suberised. This is also the case for the intermediate root-base. In the storage root the endodermis is never thickened. In general, the number of cells in a T.S. of the endodermal cylinder is greater in the storage root than in the fibrous, but, as with the cortex, the numbers are not significant, there being overlapping. Thus in the fibrous root the number is from 18 to 22, reaching 25 at the base of the normal fibrous root and 28 at the base of the intermediate root. In the storage root the number varies from 25 to 32.

The pericycle of the fibrous and storage roots is, at initiation, a single layer of cells. It remains so in the fibrous root. In the storage root, however, due to secondary thickening, the pericycle may become a few cells deep opposite the xylem strands. In the fibrous root lignification of the pericycle cells takes place, sometimes all of them being involved. In the storage root lignification of the pericyclic cells never takes place.





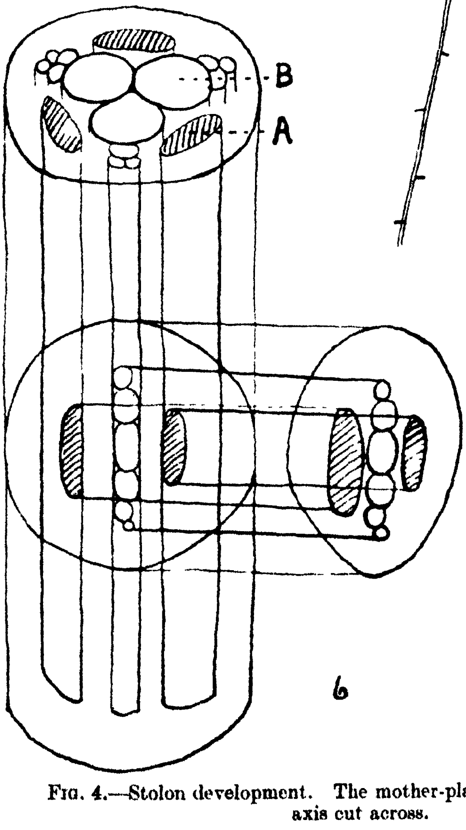


FIG. 4.—Stolon development. The mother-plant shows the flowering axis cut across.

FIG. 5.—Transition from normal fibrous root to normal storage root.

FIG. 6.—Diagram of lateral root origin.
A, phloem strand; B, xylem vessel.

The fibrous roots are generally triarch. The storage roots may be diarch, triarch, tetrarch or pentarch. They sometimes show a distelic condition, each stele giving rise to a separate fibrous prolongation.

The centre of the fibrous root stele is occupied by 2 or 3 large metaxylic vessels which reach 70 μ in diameter. The centre of the storage root stele is occupied by undifferentiated cells or lignified parenchyma. The bases of the fibrous roots show 4 or 5 central metaxylic vessels. The bases of the intermediate roots show 8 to 10 such vessels, approaching in the number of cells the central stelar tissue of the storage root. The fact that vessels are present in the centre of the stele of intermediate roots, together with other features already noted, shows the essentially fibrous nature of such roots.

In the fibrous root no secondary thickening is found. In the storage root secondary thickening is prominent to the inside of the phloem strands. It sometimes extends into the pericycle over the xylem arcs. In all cases the elements produced remain meristematic.

The Absciss Layer between the Storage Region and the Fibrous Prolongation.

Transition from the storage to the fibrous region is abrupt in the mature storage root, and is marked internally by an absciss layer. The cells of the absciss layer arise by divisions in the cortical cells, the inner surface of whose walls shows a strong deposition of suberin. On either side of this layer the cortical cells show cell divisions but no suberisation. The thickened endodermis of the fibrous region begins abruptly on the distal side of the abscission layer. During the process of decay the fibrous prolongation breaks off from the storage part, leaving a brown scar at the latter's tip.

Anatomy of Lateral Root Production.

The stele of the lateral root is diarch, the plate of xylem being bounded on either side by a strand of phloem. The plane of the xylem plate is parallel to the axis of the main root. The xylem plate connects with the protoxylem of one of the xylem arcs of the main root, each of the two phloem

strands connecting with one of the two main root strands adjacent to the xylem arc (fig. 6).

The Anatomy of the Stolon Tip and Root Production.

The stolon tip is a region of contracted internodes, the first leaf being a scale-leaf, the subsequent two or three leaves being juvenile foliage leaves. As in the elongated region of the stolon, there is an increase in the number of bundles in passing from a lower to a higher internode. This is due to the splitting of stolon bundles. The stolon bundle may divide into three, one part going out as a leaf-trace, the other two parts remaining in the stolon. The stolon bundle may, on the other hand, split into two parts only, one going out as a leaf-trace, one remaining in the stolon. If all the three traces of a scale-leaf arose in the latter manner, there would be no increase. However, investigations showed that an increase is the normal occurrence.

The roots arise both at the nodes in connection with the departure of leaf-traces and in the contracted internodes. Root production has nothing to do with the increase in the number of bundles, which is of earlier origin.

As has been seen, the first roots to be produced are normally all storage. When these have matured the primordia of the subsequent fibrous roots are laid down just above them.

All the root primordia arise in the inner cortex just outside the vascular bundles (2).

The root stele connects with the vascular system of the stolon in one of two ways:

1. It may connect laterally with a single bundle.
2. It may first split into two, each part connecting laterally with a stolon bundle.

Secondary thickening takes place in the bundles of that part of the stolon showing storage roots. Interfascicular cambium is also developed. Only meagre secondary thickening is shown in the bundles of the region giving rise to fibrous roots.

The bundles in the internodal region of the stolon show complete sheaths of lignified tissue. At the nodes, owing to leaf-trace departure, the sheath becomes broken. In the

root-producing region further reduction of the stereome takes place, the strengthening tissue being confined to the outside and inside edges of the bundles. In the storage-root region the inner lignified tissue is augmented by the fanlike expansion into the outer pith of the central lignified stelar tissue of the storage root.

Discussion.

A notable feature of the life-history of this plant is the sacrifice of seed formation in favour of an extremely efficient system of vegetative propagation, which not only allows of the production of new daughter-plants but also of the survival of the mother-plant.

The differences between the storage and fibrous roots can be explained on a developmental and functional basis. Thus the fibrous root shows pronounced and continued apical growth, is late in producing root-hairs,. and is profuse in lateral root development. The storage root is early in the production of root-hairs and often fails to develop lateral roots. The storage roots show a transition from a type with an elongated fibrous prolongation to a type with a stubby storage base and a short fibrous prolongation. Growth seems to have been transferred from length to breadth. This is indicated by the radial expansion of the cortical cells and by the presence of secondary thickening.

In anatomical features the results of the change from a conducting and absorbing root to a storage root are seen. Thus the cortex is greatly expanded and utilised for starch storage. Central metaxylic vessels are absent, the whole xylem being meagre in amount.

Apart from starch production, the incoming carbohydrate is utilised in secondary thickening and in lignification of the central tissue of the stele.

In connection with the origin of the two types of root, they both arise in the same manner and act in the same way towards the lignified sheath of the stolon bundles. The secondary thickening in the region of stem giving rise to storage roots is due to the presence of the storage roots. The secondary thickening of the bundles in the fibrous root-producing region is a continuation of that of the storage root-producing region below.

In conclusion, it may be noted that as far as quantitative data go a transition from the fibrous root through the intermediate root to the storage root is seen. Qualitative data, however, separate off the storage root from the fibrous and intermediate roots.

The writer wishes to express his indebtedness for facilities and assistance provided him in the Botanical Department, St. Andrews University, where this investigation was carried out.

SUMMARY.

1. The development of the plant and the anatomy of the underground system is described.

2. The development of the roots is described, differences between fibrous- and storage-root development being noted.

3. The differences between and the resemblances among fibrous, intermediate, and storage roots in anatomy are described.

4. The anatomy of the absciss layer and lateral root production is detailed.

5. The anatomy of root production at the stolon tip is discussed.

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THE ROSE FLORA OF THE INNER AND OUTER HEBRIDES AND OF OTHER SCOTTISH ISLANDS. By J. W. HESLOP HARRISON, D.Sc., F.R.S., and ETHEL BOLTON, M.Sc.

(Read 16th June 1938.)

In spite of its obvious interest, but little research work has been done on the distribution of the members of the genus *Rosa* in the Western Islands of Scotland. However, in 1934 the task of preparing a comprehensive County Flora of the Inner and Outer Hebrides was undertaken by the Department of Botany, King's College, University of Durham, and various expeditions despatched to carry out the necessary investigations.

Whilst these researches were in progress, the duty of studying the roses was assigned to the present writers, so that a large number of islands has been examined exhaustively. Furthermore, large collections have been made for our purposes in other areas by Mrs. G. Heslop Harrison, Mrs. C. W. Heslop Harrison, Dr. W. A. Clark, and Dr. G. Heslop Harrison. Thus no fewer than twenty-eight islands have been visited and their rose floras determined.

Of these, Bute belongs to v.-c. 100 (Clyde Isles); Mull, Tiree, and Coll to v.-c. 103 (Mid-Ebudes); Skye, South Rona, Raasay, Fladday, Scalpay, Longay, Pabbay, Soay, Canna, Sanday, Rhum, Muck, Eilean nan Each, and Eigg to v.-c. 104 (North Ebudes); Handa to v.-c. 108 (West Sutherland); and Harris, Taransay, North Uist, South Uist, Eriskay, Fuday, Barra, Mingulay, and Berneray * to v.-c. 110 (Outer Hebrides).

During the course of the work many interesting varieties, some apparently new to Britain, were discovered, but other observations much more important than these were made.

Of recent years, the trend of opinion has been to regard *Rosa glaucophylla* (*glauca*) and *Rosa caesia* (*coriifolia*) as glabrous and pubescent phases, respectively, of the same species. With this view we formerly concurred, and Heslop Harrison (1920) went so far as to employ the name *Rosa*

* Berneray in the Barra Isles group is here intended.

Afzeliana to cover the two roses in question. However, the same writer (1930) pointed out that, as one passed westward in Northumberland and Durham, *R. caesia* thins out much earlier than *R. glaucophylla*. Conversely, on the coastal sand-dunes, large colonies of *R. caesia* flourish, whilst *R. glaucophylla* fails as a significant element in the rose flora.

In much the same way, *Rosa canina* and *R. dumetorum* have been regarded as specifically identical, and here again the very same type of observation has been made. *R. canina* proceeds much farther westward in our counties than does *R. dumetorum*.

The rose populations of the Inner and Outer Hebrides yield abundant corroborative evidence of the same order. Whilst *Rosa glaucophylla* occurs throughout the islands appertaining to v.-c. 104 and reaches the Outer Islands, only on Pabbay, lying close to the Ross-shire coast, do forms assignable to *R. caesia* grow. In the case of the other pair, although *R. canina* in various guises is of free occurrence on most of the Inner Islands, and has even been detected on several of the Outer Hebrides, only from Rhum and Sanday has any variety of *R. dumetorum* been reported.

Clearly, physiological as well as morphological differences exist between *Rosa glaucophylla* and *R. caesia*, and between *R. canina* and *R. dumetorum*. We therefore urge that, assessing these differences at their lowest possible value, *R. glaucophylla* and *R. caesia* must be regarded as forming distinct subspecies, and that a similar rank must be assigned to *R. canina* and *R. dumetorum*. Our preference, adopted in this paper, is to regard them as species.

An important circumstance recalling these observations, and affording some degree of support to our conclusions, was noted in investigating the distribution of *Rosa Sherardi*. Throughout certain areas in Skye, South Rona, Raasay, Scalpay, Longay, and Pabbay the endemic form *glabrata* tends to replace the ordinary pubescent varieties. Almost certainly the same forces as govern the ranges of *R. canina* and *R. glaucophylla* on the one hand, and of *R. dumetorum* and *R. caesia* on the other, are at work here.

In compiling our lists we have preferred to follow the nomenclature of the second edition of Druce's "British Plant List" in respect to *Rosa caesia* and its varieties. In our

opinion, the treatment accorded them in that work is definitely superior to that of either the eleventh edition of the "London Catalogue" or of Wolley-Dod's "Revision of the British Roses." Further, to a considerable extent Heslop Harrison's (1920) arrangement has been adopted in the case of *Rosa Sherardi*. In the latter connection, too, it seems proper to emphasise that the so-called new combinations proposed in Wolley-Dod's work (November 1930) are antedated by those of Heslop Harrison, whose paper appeared in the "Naturalist" for April 1930.

Rosa canina L. Agg.

GROUP LUTETIANAE.

(*a*) Var. *lutetiana* Baker. Never very common, but noticed on Bute, Mull, Longay, Rona, Rhum, Canna, Soay, Harris and South Uist.
   (1) f. *lasiostylis* Borb. Skye, North Raasay, and on Loch Scresort, Rhum.
(*b*) Var. *sphaerica* (Gren.) Dum. Sparingly on Rhum and Fuday.
(*c*) Var. *flexibilis* Déségl. Bute, Skye, Clachan, Raasay, Eigg and South Uist.
(*d*) Var. *oxyphylla* Rip. Rona and Kinloch, Rhum.

GROUP TRANSITORIAE.

(*e*) Var. *spuria* Pug. Fearns, Raasay, Rhum and South Uist.
   (1) f. *syntrichostyla* Rip. Bute, Mull, Skye, Northern Raasay, Rona, Longay.
(*f*) Var. *insignis* B. and C. Camas nan Gall, Soay.
(*g*) Var. *rhynchocarpa* Rip. Rhum, near Kinloch.
(*h*) Var. *globularis* Franch. Bute, South Scalpay and Raasay.
(*i*) Var. *ramosissima* Rau. Northern Raasay and South Scalpay.

GROUP DUMALES.

(*j*) Var. *dumalis* Bechs. Bute, Mull, North Raasay, Rona, Rhum, Canna, Soay, and Harris.
   (1) f. *viridicata* Pug. Balachuirn, Raasay and Sanday.
   (2) f. *cladoleia* Rip. North Fearns, Raasay and Rhum.

(*k*) Var. *biserrata* Mer. Bute, Point of Eyre, Raasay, Canna, and South Uist.

(1) f. *sphaeroidea* Rip. Balachuirn, Raasay.

(*l*) Var. *Carioti* Chab. West Raasay, Scalpay, Rhum, and Hellisdale and Loch Eynort, South Uist.

(*m*) Var. *recognita* Rouy. Pabbay.

(*n*) Var. *fraxinoides* H. Br. Skye, East Raasay, Scalpay, and Pabbay.

(*o*) Var. *Schimperti* Hofm. Common on Bute, Mull, Skye, Raasay, and South Scalpay.

(*p*) Var. *sylvularum* Rip. Bute, Fearns, Raasay.

(1) f. *adscita* Déségl. Brochel and Clachan, Raasay, and Fladday.

GROUP ANDEGAVENSES.

(*q*) Var. *verticillacantha* Mer. Common on North Raasay and Eigg.

(*r*) Var. *Schottiana* Ser. North and South Fearns, Raasay.

R. dumetorum Thuill. Agg.

GROUP PUBESCENTES.

(*a*) Var. *urbica* (Lem.) W.-Dod. Rare, Kinloch, Rhum.

(*b*) Var. *hemitricha* (Rip.) W.-Dod. On Sanday only.

R. glaucophylla Winch. Agg.

(*a*) Var. *Reuteri* (God.) H.-Harr. Common on Bute and Mull, but rarer in Scalpay, Soay, Rhum, Sanday and Canna; sparingly on the cliffs of Mingulay as well as in North and South Uist, Eriskay, Taransay and Harris.

(1) f. *transiens* (Gren.) H.-Harr. Bute, Skye, Rhum and Scalpay.

(*b*) Var. *subcristata* (Baker) H.-Harr. Fairly common on Bute, Mull, Skye, Raasay, Rona, Soay, Canna, Sanday, Muck, Eigg, Rhum, and somewhat rarer on Mingulay, North Uist, Taransay, Eriskay, South Uist and Harris.

(1) f. *jurassica* (Rouy) H.-Harr. East Raasay, Scalpay and Loch Skiport, South Uist.

(2) f. *myriodonta* (Chr.) H.-Harr. Balachuirn and Hallaig, Raasay and Eriskay.

(3) f. *adenophora* (Gren.) H.-Harr. Bute, Scalpay, Rhum and Eigg.

(*c*) Var. *stephanocarpa* (Déségl. and Rip.) H.-Harr. Bute and Plasgaig, Rhum.

GROUP SUBCANINAE.

(*d*) Var. *subcanina* (Chr.) H.-Harr. Not uncommon on Raasay, Rhum and Eigg.

(*e*) Var. *denticulata* (R. Kell.) H.-Harr. South Fearns, Raasay and Rhum.

(*f*) Var. *diodus* (R. Kell.) H.-Harr. Torran, North Raasay.

(*g*) Var. *pseudo-Haberiana* (R. Kell.) H.-Harr. Clachan, Raasay, and Eigg.

(*h*) Var. *macrocala* (Schnetz.) H.-Harr. Cliffs on Pabbay only; new to Britain.

(*i*) Var. *Wartmannii* (R. Kell.) H.-Harr. Bute only.

(*j*) Var. *ungulata* (Schnetz.) H.-Harr. Bute and Soay. New to Britain, and easily recognised by its longish woolly styles.

(*k*) Var. *Bartlettiana* H.-Harr. Found near Rudha na Roinne, Rhum.

R. caesia Sm. Agg.

(*a*) Var. *frutetorum* (Chr.) H.-Harr. Bute and Pabbay; rare on the cliffs of the latter island.

(*b*) Var. *Watsoni* (Baker) H.-Harr. Bute.

(*c*) Var. *winchiana* H.-Harr. Bute.

(*d*) Var. *Bakeri* (Déségl.) H.-Harr. Bute.

GROUP SUBCOLLINAE.

(*e*) *subcoriifolia* (Barclay) H.-Harr. Bute.

R. tomentella Lem.

(*a*) Var. *sclerophylla* Sch. On Eigg; quite typical and an unexpected find, extending the known range of the form into Scotland for the first time.

R. mollis Sm. Agg.

(*a*) Var. *typica* W.-D. Common on Bute; rare near Kilmory, Rhum.

(*b*) Var. *glandulosa* W.-D. Common enough on Bute, but rare on Raasay and Rona, where a single patch, possibly only one plant, represents the form in each case; also on Taransay and South Harris.

R. Sherardi Dav.

(*a*) Var. *typica* W.-D. Bute, Raasay, Skye, Pabbay, Eigg, Rhum and Loch Skiport, South Uist.

(1) f. *submollis* Ley. Common on Bute, Mull, Raasay, South Rona, Scalpay, Soay, Rhum, Pabbay, South Uist, Fuday, Eriskay and Barra.

(2) f. *pseudomollis* Ley. Common on Bute, Mull, and Raasay; rarer on Scalpay, but ascending to 700 feet on inland cliffs there, Pabbay, Canna, Rhum, Muck, Eigg, Soay, Coll, Tiree, Barra, North and South Uist, and Harris.

(3) f. *uncinata* Lees. A single bush near Clachan, Raasay; also rare on Canna, Rhum, Muck and Pabbay.

(*b*) Var. *omissa* (Déségl.) H.-Harr. Bute, not uncommon, sparingly on Rona, Raasay, Scalpay, Eigg, Muck, Rhum, Soay, Coll, North and South Uist.

(*c*) Var. *Woodsiana* (Groves) H.-Harr. Scattered on Rona, Raasay, Scalpay, and Pabbay.

(*d*) Var. *suberecta* (Ley) H.-Harr. Of somewhat northerly distribution on Raasay; also on Eigg and Skye.

(*e*) Var. *glabrata* (Ley) H.-Harr. Skye, Rona, Raasay, Scalpay, and Pabbay; common enough and surprisingly variable.

(*f*) Var. *eminens* H.-Harr. Allt Liath, Scalpay.

(*g*) Var. *cinerascens* (Dum.) H.-Harr. Rare on South Rona.

(*h*) Var. *perthensis* (Rouy.) H.-Harr. Fearns, Raasay.

(*i*) Var. *Cookei* H.-Harr. A very noteworthy endemic form found on rocks, etc., generally overhanging the sea, in the south of South Uist; locally quite common (Harrison, 1938).

R. Sherardi × **R. verticillacantha.**

A very fine and new hybrid found near Torran, Raasay; we call it × *R. insularum.* In spite of its lavish display of flowers, most of its fruits fall. Those remaining rarely carry more than one seed.

R. spinosissima L.

(*a*) Var. *typica* W.-D. Abundant on Skye, Mull, Scalpay, Soay, Canna, Rhum, Eigg, Muck, Eilean nan Each, Coll, Tiree, Barra; also on Handa. On Soay it forms dense masses as an undershrub in the birch copses in the northern half of the island.

(*b*) Var. *pimpinellifolia* L. Also on Skye, Scalpay, Soay, Muck, Eilean nan Each, Rhum, Sanday, Coll and Handa.

(*c*) Var. *Ripartii* Déségl. A very well-marked form of this occurs on Scalpay and Eigg.

(*d*) Var. *inermis* DC. Rare on Canna.

(*e*) Var. *rosea* Koch. Very beautiful forms of this variety occur on the south of Muck and on Eilean nan Each.

(*f*) Var. *turbinata* Lindl. Near Papadil, Rhum.

R. spinosissima × **R. canina** Agg.

South Fearns, Raasay.

R. spinosissima × **R. Sherardi** Agg.

Scalpay, Soay, Rhum, Eigg and Coll; also on Raasay in spite of the absence of *R. spinosissima* on that island. No doubt bees from Scalpay, a mile away across the Caol Scalpay, are responsible.

R. rubiginosa L. Agg.

Var. *typica* W.-Dod. On the slopes of Mullach Mor, Rhum.

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THE MARINE ALGAE OF BARRA. By JAMES SINCLAIR, B.Sc.

(Read 16th October 1938.)

During the summer of 1935 and 1936 I visited Barra with the object of studying the seaweeds, obtaining a list of the species, and noting their distribution.

The island of Barra lies near the southern end of the Outer Hebrides in latitude 56° 58′–57° 5′ N., and in longitude 7° 20′–7° 34′ W. It is eight miles long and its greatest breadth is five miles.

The coast is very irregular, being broken by headlands and inlets. On the west are a few sandy bays, but elsewhere it presents to the Atlantic a series of rocky cliffs torn with fissures and pierced with caves. The east coast is much indented about the middle with several long inlets, elsewhere it is formed of sandy bays and low rocky cliffs.

Algae were collected all round the coast, but especially at stations representative of various algal communities. These are indicated on the accompanying map.

LIST OF BARRA MARINE ALGAE COLLECTED.

CHLOROPHYCEAE.

Endoderma Flustrae Batt. On *Sertularia pumila*. The gorge, Loch Obe.

Enteromorpha clathrata J. A. Agardh. Rocks near high-water mark. Bàgh Beag.

Enteromorpha compressa Grev. Rocky pools on west coast. Halaman Bay.

Enteromorpha intestinalis Link. Rocks near high-water mark. Bàgh Beag.

Enteromorpha marginata J. A. Agardh. Attached to cockle shells. Tràigh Mhòr.

Ulva lactuca Linn. var. *latissima* DC. Tràigh Mhòr. Common.

Prasiola stipitata Suhr. On the top of a large boulder. Bàgh Beag.

Cladophora albida Kutz. Rocks and pools. Halaman Bay.

Cladophora rupestris Kutz. Cosmopolitan in distribution.

Chaetomorpha tortuosa Kutz. Loch Obe gorge. Bun ant-Sruith.

Chaetomorpha litorea Cooke. Salt marsh, Heath-Bank, North Bay.

Chaetomorpha melagonium Kutz. Rocky pools. Bun ant-Sruith. Small bay south-west of Àrd Rudha Mòr. South of Greian Head.

Bryopsis plumosa C. A. Agardh. Crevice in a rock. Very rare. Bun ant-Sruith.

Vaucheria Thuretii Woron. Muddy bottom of loch. Loch Obe.

Codium tomentosum Stackh. Rocky pools. Ruleos. Halaman Bay and West coast.

PHAEOPHYCEAE.

Ectocarpus confervoides Le Jol. North Bay (Bay of Hirivagh). Plurilocular sporangia present. Common round the coast.

Ectocarpus fasciculatus Harv. Attached to old fronds of *Himanthalia lorea*. Halaman Bay. Unilocular sporangia present.

Ectocarpus tomentosus Lyngb. On *Fucus vesiculosus*. Bun ant-Sruith. Ruleos. Rocks south of Greian Head.

Elachistea fucicola Fries. On *Fucus vesiculosus*. North Bay, Halaman Bay, Bàgh Beag. Common.

Elachistea scutulata Duby. On *Himanthalia lorea*. Rocks south of Greian Head. Small bay south-west of Àrd Rudha Mòr.

Petrospongium Berkeleyi Naeg. Rocks south of Greian Head. Rare.

Leathesia difformis Aresch. Attached to *Laurencia pinnatifida*. Loch Obe gorge. Bun ant-Sruith. Ruleos. Rocks south of Greian Head. Bàgh Beag.

Myriactis Areschoughii Batt. On the thongs of *Himanthalia lorea*. Halaman Bay. Rare. Unilocular sporangia present.

Chordaria flagelliformis C. A. Agardh. Tràigh Cille-Bharra. Small bay south-west of Àrd Rudha Mòr.

Castagnea virescens Thur. Rocky pools at half-tide. Halaman Bay. Tràigh Scurrival.

Castagnea Zosterae Thur. Epiphytic on *Zostera marina*. Tràigh Scurrival. Unilocular sporangia plentiful.

Mesogloia vermiculata Le Jol. Attached to stones and cast up in great quantity. Tràigh Scurrival. Tràigh Mhòr.

Myrionema strangulans Grev. Epiphytic on *Ulva*. Washed up. Tràigh Scurrival. Epiphytic on *Rhodymenia palmata*. Tràigh Eais.

Myrionema strangulans Grev. var. *punctiforme* Holm. et Batt. Globose patches on *Enteromorpha* at Tràigh Eais and on *Ceramium rubrum* at the same station.

Ralfsia verrucosa Aresch. Coriaceous expansions on cockle and mussel shells. Tràigh Mhòr. Unilocular sporangia and paraphyses present.

Desmarestia viridis Lamour. Tràigh Scurrival.

Desmarestia aculeata Lamour. Tràigh Scurrival.

Desmarestia ligulata Lamour. Tràigh Scurrival.

Dictyosiphon hippuroides Kutz. On *Chordaria flagelliformis*. Small bay south-west of Àrd Rudha Mòr.

Aspercoccus fistulosus Hook. Rocky pools. Tràigh Mhòr. Bàgh Beag. On *Fucus serratus*. Unilocular sporangia present.

Aspercoccus bullosus Lamour. One specimen washed up at Tràigh Eais.

Myriotrichia filiformis Harv. Epiphytic on *Aspercoccus fistulosus*. Bàgh Beag. Epiphytic on *Chorda Filum* Tràigh Mhòr.

Phyllitis Fascia Kutz. Epiphytic on the fronds of *Himanthalia lorea*. Rocky pool near low-water mark. Halaman Bay. Rare.

Scytosiphon lomentarius J. A. Agardh. Halaman Bay. Small bay south-west of Àrd Rudha Mòr.

Litosiphon pusillus Harv. Epiphytic on *Chorda Filum*. Tràigh Eais.

Litosiphon Laminariae Harv. In tufts on *Alaria esculenta*. Washed up in Tràigh Eais.

Phloeospora brachiata Born. Epiphytic on *Rhodymenia palmata*. Bàgh Beag. Unilocular sporangia present. Rare.

Sphacelaria cirrhosa C. A. Agardh. var. *pennata* Hauck. Washed up in Tràigh Scurrival.

Cladostephus spongiosus J. G. Agardh. Ruleos. Tràigh Eais.

Cladostephus verticillatus J. G. Agardh. Tràigh Scurrival.

Chorda Filum Lamour. Abundant everywhere, but best developed in still water.

Chorda Filum Lamour var. *thrix* Hooker. Attached to shells and small stones at Tràigh Mhòr. Common.

Laminaria saccharina Lamour. Halaman Bay. Tràigh Scurrival. Common.

Laminaria digitata Lamour. Forms a continuous zone fringing the cliffs beyond Bàgh Beag, in deeper water. Also at Ruleos, Bun ant-Sruith and Loch Obe.

Laminaria Cloustoni Edmonston. Washed up in vast quantities at Cliad on the west coast.

Saccorhiza bulbosa De la Py. Washed up. Tràigh Scurrival. Common.

Alaria esculenta Grev. Rocky pools at Halaman Bay. Common.

Dictyota dichotoma Lamour. Washed up in Tràigh Scurrival.

Fucus spiralis Linn. Near high-water mark. Loch Obe. North Bay. Halaman Bay.

Fucus ceranoides Linn Streams entering Loch Obe and Bàgh Beag. Plants with receptacles. Fairly common.

Fucus ceranoides Linn. var. *Harveyanus* Kjellm. Bàgh Beag. Rare.

Fucus vesiculosus Linn. Everywhere.

Fucus vesiculosus Linn. var. *angustifolius* Turn. Rocks at north end of Tràigh Eais. Receptacles present. Common.

Fucus vesiculosus Linn. var. *balticus* J. G. Agardh. Salt marsh. Heath Bank and below church at North Bay.

Fucus vesiculosus Linn. var. *vadorum* Aresch. Coast line opposite Orosay. Bàgh Beag.

Fucus serratus Linn. Cosmopolitan. Receptacles present.

Ascophyllum nodosum Le Jol. Cosmopolitan. Receptacles present.

Pelvetia canaliculata Dcne. et Thur. Cosmopolitan. Receptacles present.

Himanthalia lorea Lyngb. East and west coast where surf is present.

Halidrys siliquosa Lyngb. Loch Obe. Bàgh Beag. Halaman Bay. Greian Head.

Cystoseira ericoides C. A. Agardh. One specimen cast up. Tràigh Eais.

RHODOPHYCEAE.

Porphyra umbilicalis J. G. Agardh. Rocks sloping abruptly into the sea. North-west end of Bàgh Beag.

Acrochaetium virgulatum J. G. Agardh. Attached to *Ceramium rubrum*. Tràigh Eais.

Helminthora divaricata J. G. Agardh. A few specimens cast up in Seal Bay and Tràigh Scurrival.

Gelidium pusillum Le Jol. Creeping in a muddy substratum and concealed under rocks from sunlight. North Bay. Rare.

Gelidium attenuatum Thur. Deep pool. Halaman Bay. Rare.

Bonnemaisonia asparagoides C. A. Agardh. Bun ant-Sruith. Rare.

Gloiosiphonia capillaris Carm. Small bay south-west of Àrd Rudha Mòr. Plants with cystocarps. Rare.

Dumontia incrassata Lamour. North-west end of Bàgh Beag. South-west of Greian Head.

Furcellaria fastigiata Lamour. Tràigh Scurrival. Washed up in great quantities along the strand of coast from Dùn Chlif to Cliad.

Polyides rotundus Grev. Ruleos. Rare.

Petrocelis cruenta J. G. Agardh. Rocks beyond Halaman Bay. Rare.

Lithophyllum pustulatum Foslie. Epiphytic on *Phyllophora epiphylla* Batt. Halaman Bay. Conceptacles with bisporangia.

Lithothamnion calcareum Aresch. Halaman Bay. Rare.

Lithothamnion lichenoides Foslie. Rocks at low-water mark. Bun ant-Sruith.

Lithothamnion polymorphum Foslie. Common round west coast and at Loch Obe.

Corallina officinalis Linn. Very common. West coast and exposed parts of east coast.

Corallina officinalis Linn. var. *compacta* Batt. Dense hemispherical cushions on surf area. Halaman Bay.

Delesseria sanguinea Lamour. Halaman Bay. Washed up in Tràigh Scurrival.

Membranoptera alata Kylin. Washed up. Tràigh Eais.

Phycodrys rubens Batt. Washed up. Cliad and Dùn Chlif.

Nitophyllum punctatum Grev. Washed up. Tràigh Eais. Tetraspores present.

Odonthallia dentata Lyngb. Washed up. Tràigh Scurrival. Common.

Laurencia caespitosa Lamour. Bottom of deeper pools. Halaman Bay. Rare.

Laurencia pinnatifida Lamour. North-west outer part of Bàgh Beag. Halaman Bay. Rocky parts of east coast. Common.

Polysiphonia urceolata Grev. Rock pools. Halaman Bay. Common.

Polysiphonia urceolata Grev. var. *patens* J. G. Agardh. Rocks beyond Halaman Bay. Common.

Polysiphonia fastigiata Grev. Abundant wherever *Ascophyllum nodosum* exists.

Polysiphonia Brodiaei Grev. Washed up. Tràigh Mhòr. Cystocarps present. Rare.

Brongniartella byssoides Bory. Washed up. Tràigh Scurrival. Tetrasporangia present. Common.

Heterosiphonia plumosa Batt. Washed up in quantity. Tràigh Scurrival. Attached to rocks beyond Halaman Bay and at Bun ant-Sruith.

Griffithsia flosculosa Batt. Bun ant-Sruith. Rare.

Rhodochorton floridulum Naeg. Loch Obe.

Callithamnion Hookeri C. A. Agardh. Between Ersary and Orosay. Tetraspores present.

Callithamnion arbuscula Lyngb. Exposed rocks beyond Halaman Bay.

Callithamnion tetragonum C. A. Agardh. Washed up in Seal Bay.

Callithamnion granulatum C. A. Agardh. Bottom of a deep pool. Dùn Chlif. Fruiting condition very good. Tetraspores present.

Plumaria elegans Schmitz. Mixed up with *Callithamnion Hookeri.* Orosay.

Ptilota plumosa C. A. Agardh. Epiphytic on the stipes of *Laminaria Cloustoni.* Chad. Rock pools. Halaman Bay.

Ceramium strictum Harv. Loch Obe.

Ceramium diaphanum Roth. Rock pools. Tràigh Mhòr.

Ceramium rubrum C. A. Agardh. Tràigh Scurrival. Tràigh Eais. Tetraspores present.

Ceramium ciliatum Ducluz. Between Ersary and Orosay. Rare.

Ceramium acanthonotum Carm. Halaman Bay.

Chondrus crispus Lyngb. North Bay. Tràigh Mhòr. Bàgh Beag. Common.

Gigartina stellata Batt. Outer part of Bàgh Beag. Common.

Phyllophora epiphylla Batt. Halaman Bay.

Ahnfeltia plicata Fries. Tràigh Scurrival. Plants with monospore pustules (see "Handbook of British Seaweeds," Newton, p. 414).

Cystoclonium purpureum Batt. Washed up in quantity. Tràigh Scurrival. Bun ant-Sruith. Attached to rocks. Fruiting well developed.

Catenella repens Batt. Crevices of rocks. Loch Obe gorge. No fruit developed.

Rhodymenia palmata Grev. Deeper water. Outer part of Bàgh Beag. Common.

Lomentaria articulata Lyngb. Tràigh Mhòr, near Orosay. Bun ant-Sruith.

Chylocladia kaliformis Hook. Halaman Bay and rocky parts of east coast.

Chylocladia kaliformis Hook. var. *patens* Harv. Tràigh Cille-Bharra.

Chylocladia ovata Batt. Bun ant-Sruith. Halaman Bay.

Plocamium coccineum Lyngb. Abundant in the deep water, while the beach between Dùn Chlif and Chad was strewn with this plant. Cystocarps present.

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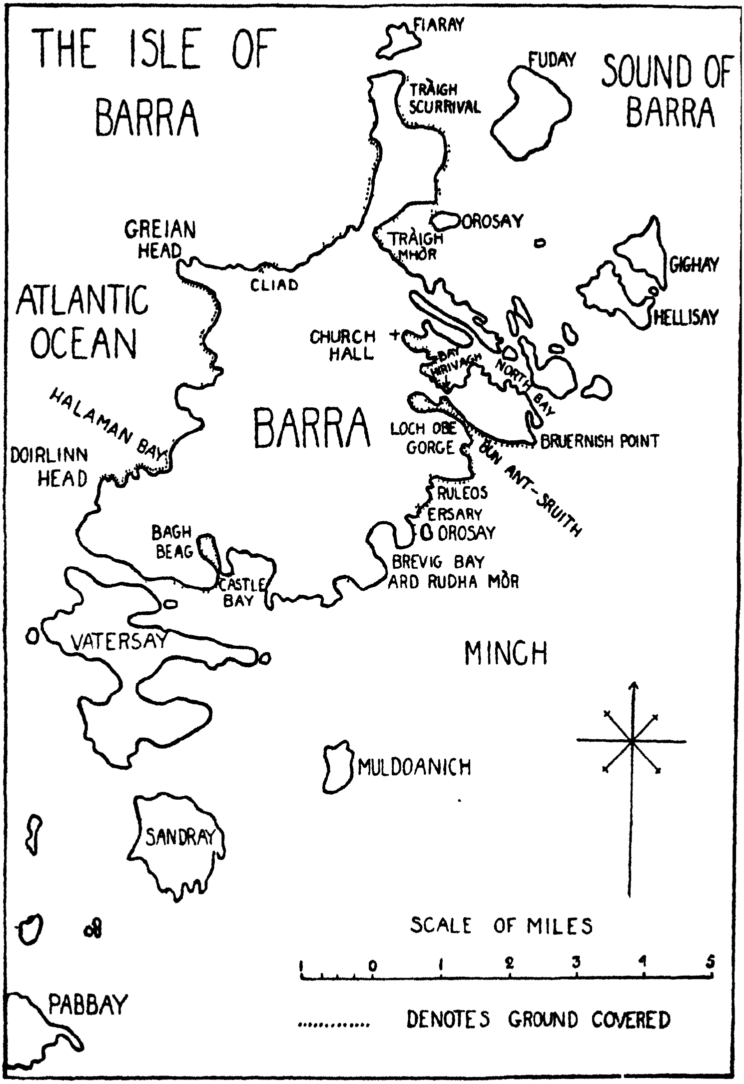

THE ISLE OF BARRA
SOUND OF BARRA
ATLANTIC OCEAN
FIARAY
FUDAY
TRAIGH SCURRIVAL
OROSAY
TRAIGH MHOR
GREIAN HEAD
CLIAD
GIGHAY
HELLISAY
CHURCH HALL
BAY HIRIVAGH
NORTH BAY
HALAMAN BAY
BARRA
LOCH OBE
GORGE
BRUERNISH POINT
BUN ANT-SRUITH
DOIRLINN HEAD
RULEOS
ERSARY
OROSAY
BAGH BEAG
CASTLE BAY
BREVIG BAY
ARD RUDHA MÒR
VATERSAY
MINCH
MULDOANICH
SANDRAY
PABBAY
SCALE OF MILES
1 0 1 2 3 4 5
.... DENOTES GROUND COVERED

The Spores of Pteridophyta, with Observations on Microspores in Coals of Carboniferous Age. By Elizabeth M. Knox, M.A., B.Sc. (With 121 figures.)

(Read 20th October 1938.)

Introduction.

Geologists have long recognised that the spore content of some coals is frequently very high, and the relative abundance of different types of spores is likely to prove of economic importance in connection with the correlation of coal seams. No attempt has yet been made in this country to classify these fossil spores beyond an artificial grouping into a number of types distinguished by such general morphological characters as size, shape, relative thickness of wall and ornamentation. Such a scheme, when improved and extended, may well be all that is necessary from the economic standpoint, but the botanical interest remains, and from this point of view the interpretation of the fossil spores may be expected to derive some enlightenment from an examination of modern representatives. This aspect of the subject became very evident during the author's investigations on the microspore content of the coals of the Productive Coal Measures of Fife, and the need was felt for some general survey of the spores of living Pteridophyta, with which those of Carboniferous age might be compared. Although extensive studies have been undertaken recently on the pollen grains of modern flowering plants and on the pollen preserved in peats and lignites, there are surprisingly few references in recent botanical literature to the spore characters of vascular cryptogams. Since no general comparative account of these is available, the present paper aims at providing students of fossil spores with some basis for comparison with recent types. It is not suggested that any close phyletic comparison is to be drawn between the spores of living plants and those of Carboniferous age, but the results of the present investigation indicate that some striking similarities exist. Whether these denote any relationship it is not possible to say. Homoplasy is so general in the

plant world that the resemblances may be more apparent than real, and the same type of spore has probably appeared more than once in quite unrelated families.

The groups here dealt with are the Psilotales, Equisetales, Lycopodiales, and those families of the Filicales which are held to be relatively primitive and grouped together by Bower as the Simplices and Gradatae. Although only a limited amount of material of some genera has been available for examination, it is believed that a sufficiently large number of species has been dealt with to justify a general account of spore morphology in the more primitive members of the Pteridophyta as a whole. Descriptions of spore structure have been given as briefly as possible, but numerous examples have been illustrated as likely to be more helpful to others engaged in similar work. In a number of the illustrations shading is shown by hatching and is not a feature of the spore ornamentation.

PSILOTALES.

The two genera included in this family, represented by *Tmesipteris tannensis*, *Psilotum triquetrum* and *Psilotum complanatum*, possess bilateral or bean-shaped spores, an interesting contrast to the spherical or tetrahedral spores of the Psilophytales (Kidston and Lang, 1917). In both species of *Psilotum* the spores show a similar range in size, averaging $55\ \mu \times 30\ \mu$, but in *Tmesipteris tannensis* they measure on the average $75\ \mu \times 35\ \mu$. In all three species the spores are characterised by thin walls ($3\ \mu$ to $5\ \mu$ thick) and by a single longitudinal ridge. In *Psilotum* the spore surface is rough, and in both species short spicules appear irregularly (fig. 1). In *Tmesipteris* the wall is finely granular (fig. 2). The granular appearance of the spores and their general similarity throughout the family are remarked upon by Pritzel (1902), but he makes no reference to the spicules in *Psilotum*.

EQUISETALES.

The spores of 15 species of *Equisetum* have been examined. They exhibit remarkable uniformity in structure, being invariably spherical, $30\ \mu$ to $35\ \mu$ in diameter, and are always thin-walled (fig. 3). In all the species examined the surface

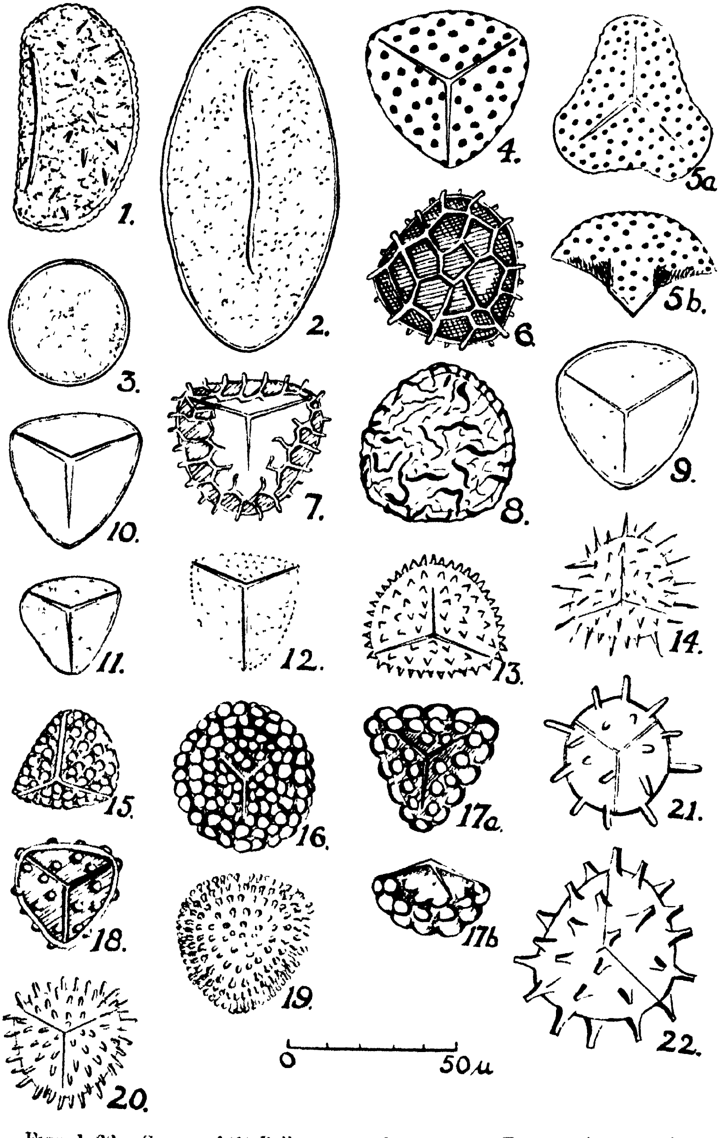
of the spore is faintly granular. The *Equisetum* type of spore is of general occurrence in coals of Carboniferous age, but it is commonly larger than the modern representative and, as might be expected, there is no trace of elaters.

LYCOPODIALES.

Lycopodium and *Phylloglossum*.

The existing homosporous Lycopodiales comprise the monotypic genus *Phylloglossum* and nearly 100 species of *Lycopodium*. In the latter, of which 40 species have been examined, the spores are tetrahedral and range in size from 30 μ to 45 μ, but in the majority of species they are 35 μ to 40 μ in diameter.

Pritzel (1902) divides *Lycopodium* into two sub-genera, *Urostachya* and *Rhopalostachya*, mainly on the basis of general morphological characters, a sub-division which has been confirmed by the more detailed study of the sporangium-bearing organs made by Sykes (1908). In Spring's (1842) monograph of the Lycopodiaceae little reference is made to spores, and in a recent paper by Henbest (1935) they are briefly described as reticulate or occasionally tuberculate. A fuller account is given by Pritzel (*loc. cit.*), who records that the spores of *Urostachya* have a pitted surface devoid of external processes, while those of *Rhopalostachya* bear reticulate flanges or, more rarely, short spines. The present study confirms these general distinctions In 20 (50 per cent.) of the species examined the spores are pitted, the pits being rather widely spaced as in *L. Phlegmaria* (fig. 4) and *L. lucidulum* (fig. 5). This type is found only in the sub-genus *Urostachya*. In other cases the spores have reticulate ridges as in *L. scariosum* (fig. 6) and *L. alpinum* (fig. 7), a condition observed in 13 (33 per cent.) of the species examined, all belonging to the sub-genus *Rhopalostachya*. Among the remaining forms investigated spores of two types occur, some exhibiting convolute ridges as in *L. diffusum* (fig. 8) occasionally disposed as to present a pseudo-reticulate appearance, others possessing smooth or slightly granular walls as in *L. ceylanicum* (fig. 9). In the reticulate forms the ornamentation is more conspicuous on the convex side than on the converging surfaces of the apical region of the spore as shown in figs. 6 and 7. Pritzel



FIGS. 1–22.—Spores of (1) *Psilotum complanatum*, (2) *Tmesipteris tannensis*; (3) *Equisetum arvense*; (4) *Lycopodium Phlegmaria*, (5 *a*) *L. lucidulum*, apical surface; (5 *b*) side view; (6) *L. scariosum*, (7) *L. alpinum*, apical view; (8) *L. diffusum*, (9) *L. ceylanicum*, (10) *Selaginella Menziesii*; (11) *S. serpens*; (12) *S. fruticulosa*, (13) *S. Galeottii*; (14) *S. xiphophylla*; (15) *S. concinna*; (16) *S. chrysocaulos*, (17 *a*) *S. mongholica*, apical surface; (17 *b*) side view; (18) *S. haematodes*; (19) *S. picta*; (20) *S. conferta*; (21) *S. Plumea*; (22) *S. spinosa*. All ×500.

refers to the occasional occurrence of bilateral types but does not cite examples.

The spores of *Phylloglossum* are tetrahedral and pitted, and it is of interest to note that they are almost indistinguishable from those of *Lycopodium Phlegmaria* (fig. 4).

Selaginella.

Selaginella is the preponderant genus of the existing ligulate heterosporous Lycopodiales and is represented at the present day by over 500 species. About 50 of these have been examined, and the following account of the microspores is based partly on the wide survey given by Hieronymus (1902). No reference will be made here to the megaspores since in the examination of coals the method adopted practically excludes these.

The microspores of *Selaginella* are relatively small, ranging from 15 μ to 50 μ, but generally speaking the range is 20 μ to 35 μ in diameter. The shape of the spore throughout the genus is invariably of the spherico-tetrahedral type and there exists great variety in ornamentation. The decoration is usually in the form of protuberances or outgrowths of the wall, and four main types can be recognised, all of which may be regarded as having been derived from a smooth-walled type, seen, for example, in *S. Menziesii* (fig. 10). Densely granular spores are found in *S. serpens* (fig. 11), while spinose forms are illustrated in *S. fruticulosa*, *S. Galeottei*, and *S. xiphophylla* (figs. 12 to 14). In the order named they exhibit an increasing degree of spinosity, and in the last-mentioned species the acicles, though widely spaced over the wall surface, attain a length of 3 μ to 5 μ. Another series, representing the tuberculate type, includes spores whose walls have rounded elevations as in *S. concinna* (fig. 15). Here the tubercles are small and closely crowded so that the surface of the spore appears rough. Where the outgrowths are more pronounced the typical tuberculate type of spore is reached as in *S. chrysocaulos* (fig. 16). In *S. mongholica* (fig. 17) and other species, however, the protuberances are coarser and more widely spaced, giving the spore a warty appearance. The third series comprises spores characterised by the presence of rodlike outgrowths. In *S. haematodes* (fig. 18), for example,

the excrescences are relatively short and the general architecture of the spore is not far removed from the tuberculate type, but in a large number of species the emergences are of considerable length, though varying in form and density, *e.g.* *S. picta*, *conferta*, *Plumea*, and *spinosa* (figs. 19 to 22).

In addition to the four types already mentioned, some species of Selaginella are distinguished by the possession of winglike extensions of the spore wall. These are commonly equatorial in position, and may extend completely round the spore as in *S. Parkeri* (fig. 23) and *S. rupestris* (fig. 24) in which the wing is apparently convoluted. These winglike outgrowths attain a considerable size in *S. megastachya* (fig. 25), where they are furnished with thickened ribs appearing as stiff projections from the spore wall. As these spores mature the thinner portions of the wing tend gradually to disappear and the ribs persist as hooklike outgrowths.

Isoetes.

The remaining genus of the Lycopodiales, *Isoetes*, includes about 60 species. The microspores are ovoid and measure about 30 $\mu \times 20$ μ, although according to Pfeiffer (1922) some of the species have larger microspores. The wall is finely granular and in some cases short bristles cover the surface as shown in fig. 26.

Within the Lycopodiales, therefore, a fairly constant distinction exists between the spore characters in the two large genera, *Lycopodium* and *Selaginella*. In the former the spores are generally pitted or reticulate, while in the latter the ornamentation takes the form of spinous, tuberculate, truncate or winglike outgrowths. All these forms have their counterpart in fossil spores of Carboniferous age, although the latter are generally larger.

FILICALES.

Ophioglossaceae.

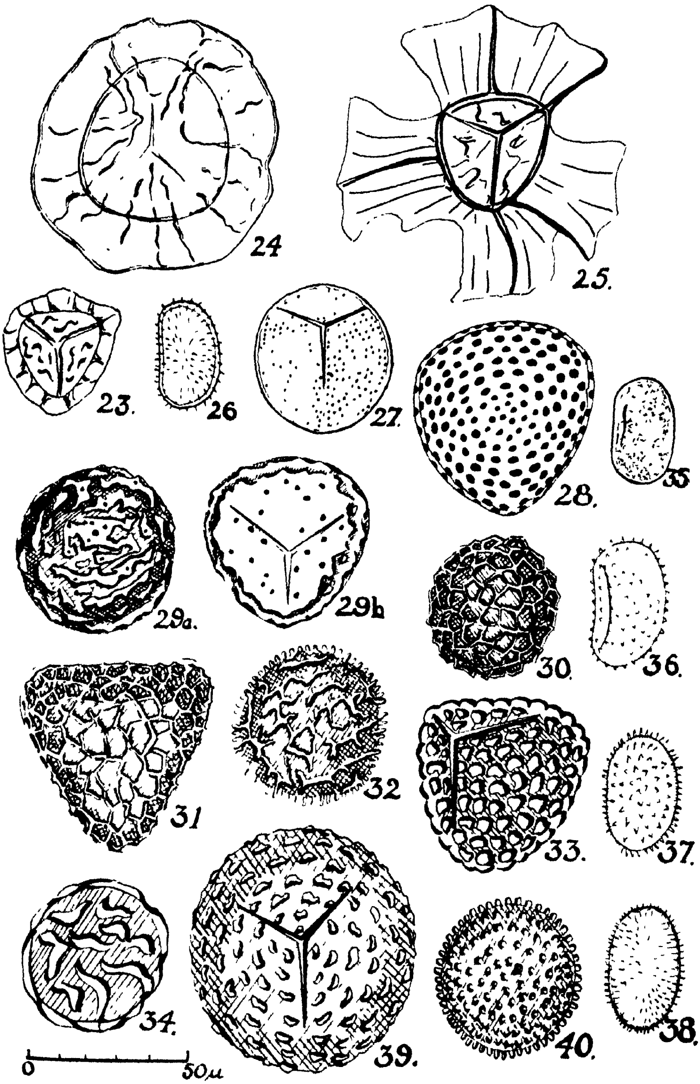
This family includes 3 genera of living plants: *Ophioglossum* with 43 species, *Botrychium* with 34, and *Helminthostachys* with one.

The spores of the *Ophioglossaceae* are most commonly tetrahedral and the output per sporangium is very large.

Campbell (1911) points out that the ripe spores "possess a moderately thick sculptured outer membrane, which is usually colourless or pale yellow, so that the masses of spores are either white or a pale sulphur-yellow tint. The ripe spore as a rule is packed with granular matter, which makes the contents appear opaque. The granular contents of the spores include numerous albuminous granules, together with more or less starch and oil." These inclusions of the spores of the *Ophioglossaceae* are certainly of very regular occurrence and are frequently so dense as to render difficult the examination of the detailed character of the wall.

In *Ophioglossum*, of which 14 species have been examined, the spores show considerable uniformity in shape, size and sculpturing. The size variation is small, ranging from 35 μ to 50 μ in diameter. Bitter (1902), however, mentions two notable exceptions to this—*O. lusoafricanum* where the spores are 80 μ, and a form of *O. Gomezianum* in which abnormally large spores also occur. It is in these and in *O. Braunii*, all African species, that Prantl found globose spores without any suggestion of tri-radiate ridges. Regarding the ornamentation of the spore in *Ophioglossum* a progression can be traced from the lightly punctate type as in *O. nudicaule* (fig. 27) to the markedly pitted form seen in *O. palmatum* (fig. 28). In some cases the pitting becomes sparse, a condition which is frequently associated with an irregular banded structure of the wall as seen in *O. crotalophoroides* (fig. 29). On the other hand, an evenly developed reticulum characterises the spore in such species as *O. pedunculosum* (fig. 30).

In *Botrychium*, of which 18 species were examined, the spore size ranges from 27 μ to 45 μ and the surface pattern is predominantly reticulate. The reticular structure is subject to considerable variation, however, passing from the typical form as in *B. boreale* (fig. 31) to the irregular network seen in *B. daucifolium*. The peculiar ornamentation in the latter species is almost exactly repeated in *Helminthostachys zeylanica* (fig. 32). In *B. matricariae* the spore wall is punctate as in *O. palmatum* (fig. 28), while the native *B. lunaria* (fig. 33) is representative of those species having warty protuberances. A further deviation is seen in *B. lanuginosum* (fig. 34), where



FIGS. 23–40.—Spores of (23) *Selaginella Parkeri*; (24) *S. rupestris*; (25) *S. megastachya*; (26) *Isoetes hystrix*; (27) *Ophioglossum nudicaule*; (28) *O. palmatum*; (29 *a*) *O. crotalophoroides*, abapical surface; (29 *b*) apical surface; (30) *O. pedunculosum*; (31) *Botrychium boreale*; (32) *Helminthostachys zeylanica*; (33) *Botrychium lunaria*; (34) *B. lanuginosum*; (35) *Marattia sambucina*; (36) *M. cicutifolia*; (37) *Danaea nodosa*; (38) *Christensenia aesculifolia*; (39) *Osmunda regalis*; (40) *Leptopteris hymenophylloides*. All ×500.

the wall is marked by irregular convolute ridges comparable to the arrangement in *Lycopodium diffusum* (fig. 8).

Throughout the family the ornamentation is usually most pronounced on the abapical surface of the spore (fig. 29 *a*) and is held by Bitter (1902) to be of systematic value. While this may be true for specific purposes, it is clear that it cannot be relied upon for the discrimination of genera.

As Bower (1926) has pointed out, "this very distinctive and circumscribed family has been related systematically with the Filicales by most writers, a position which has been definitely confirmed by a large body of facts recently acquired." An alternative relation with Lycopodiales was suggested by earlier writers, and in this connection it is of interest to note that the spore characters resemble more closely those of the Lycopodiales than the primitive ferns.

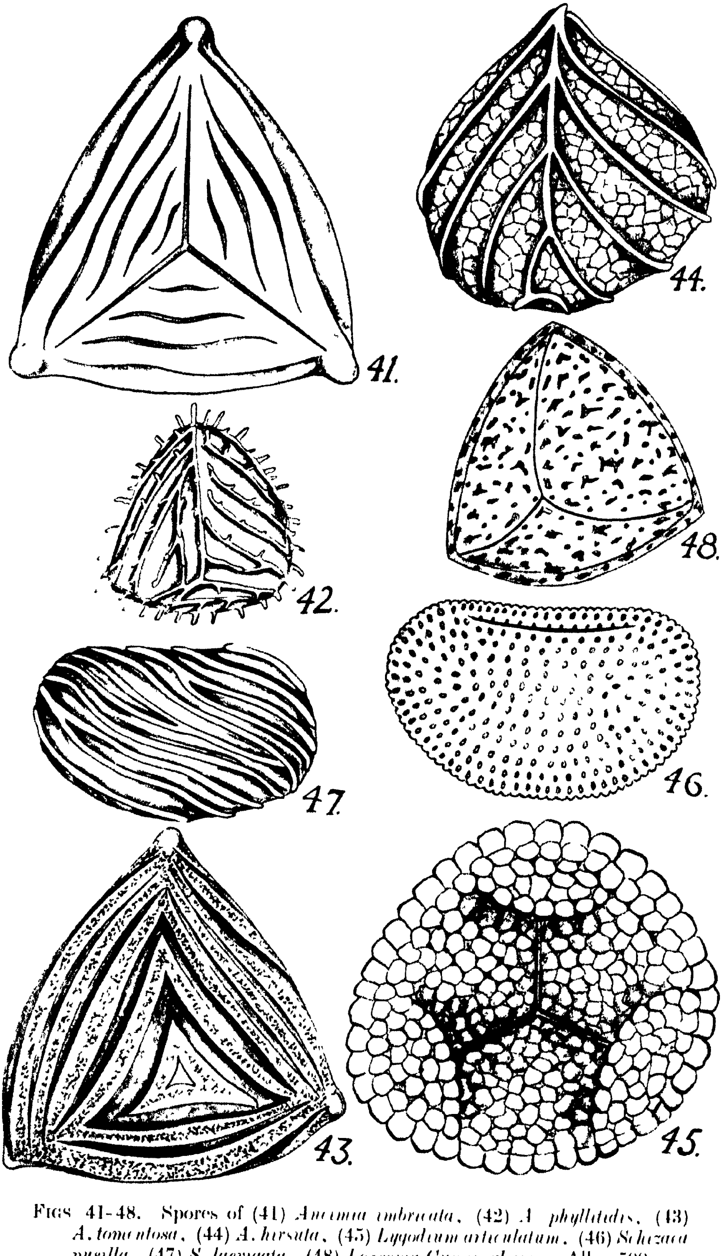
Marattiaceae.

The family comprises 7 living genera with over 100 species. Certain features of spore morphology appear to be common to the family as a whole. The spores are relatively small, ranging in size from 15 μ to 30 μ, tetrahedral or bilateral in shape, the former occurring in the majority of species of *Angiopteris*, the latter being characteristic of *Marattia*. The surface markings of the wall are granular, papillose or minutely spinose, but these several features are not restricted to any one genus. Both granular and spinose spores are seen in *Marattia* (figs. 35 and 36), and the same variation occurs in *Angiopteris*. In *Danaea* the spores are most commonly spinose (fig. 37), while *Christensenia* (fig. 38) has spores which are setose, recalling those of *Isoetes* (fig. 26).

Osmundaceae.

The family includes 3 genera, *Osmunda*, *Leptopteris*, and the monotypic *Todea*. There are 17 species altogether.

Throughout the family the spores exhibit a noteworthy uniformity, the only remarkable deviation occurring in *Leptopteris* (fig. 40), where the spores are bluntly tuberculate and about 40 μ in diameter. In *Osmunda* and *Todea* the spores attain a size of 60 μ and in all the species examined



FIGS 41–48. Spores of (41) *Anemia imbricata*, (42) *A. phyllitidis*, (43) *A. tomentosa*, (44) *A. hirsuta*, (45) *Lygodium articulatum*, (46) *Schizaea pusilla*, (47) *S. laevigata*, (48) *Loxsoma Cunninghami*. All × 500

ELIZABETH M. KNOX

the wall is marked by rough and somewhat irregular protuberances as seen in *Osmunda regalis* (fig. 39).

Schizaeaceae.

The family includes four living genera, *Schizaea* with 25 species, *Lygodium* with 26, *Mohria* with 3 and *Aneimia* with 64. Of these, there have been examined 15 species of *Schizaea*, 6 of *Lygodium*, 2 of *Mohria* and 19 of *Aneimia*.

Both the bilateral and tetrahedral types of spore occur within the family, the former being characteristic of the genus *Schizaea*, while the latter is found in the remaining three genera where the spores are relatively large, measuring from 80 μ to 115 μ, and are among the most beautiful spores of all living ferns. In *Aneimia* and *Mohria* the architecture of the spore wall is distinctive, taking the form of well-marked ridges of varying breadth, symmetrically arranged around the tri-radiate crest of the tetrahedral spore as seen in *Aneimia imbricata* (fig. 41). In *Aneimia* the ridges may be further ornamented by the presence of short, more or less blunt outgrowths as in *A. phyllitidis* (fig. 42), or by a conspicuous pitting of their surface as in *A. tomentosa* (fig. 43). On the other hand, a delicate reticulum occupies the furrows of the wall in *A. hirsuta* (fig. 44), a feature of infrequent occurrence within the genus. In *Lygodium* both granular and roughly tuberculate spores are found, *L. articulatum* (fig. 45) being remarkable for the presence of peculiar involute flanges directed towards the apex of the spore. In this genus also, according to Diels (1902), striated and reticulate forms are represented.

As already stated, the spores of *Schizaea* are of the bilateral type. They exhibit a considerable range in size from 35 $\mu \times$ 20 μ to 100 $\mu \times 65$ μ, but they are never so massive as the spores in the other three genera. The ornamentation is most commonly granular as in *S. bifida*, sometimes regularly pitted as in *S. pusilla* (fig. 46) or, more rarely, obliquely striated as in *S. laevigata* (fig. 47). Spores so well characterised as those of the *Schizaeaceae* should be recognisable with little difficulty if they were represented in the coals of Carboniferous age, but hitherto nothing resembling them has been recorded.

Gleicheniaceae.

The family includes 81 living species, most of which are referred to the genus *Gleichenia* itself. *Stromatopteris* and *Platyzoma* are monotypic.

Both bilateral and tetrahedral spores are found in *Gleichenia*, the former type varying from $30\,\mu \times 15\,\mu$ to $35\,\mu \times 20\,\mu$ in different species, the latter ranging from $25\,\mu$ to $50\,\mu$ in diameter. Among the species of *Eu-Gleichenia* examined only the tetrahedral type was found, and, in contrast to this, species belonging to the sub-genus *Dicranopteris* possess bilateral spores with the exception of *G. Bancroftii*. Throughout the genus spore ornamentation is practically absent, the spores being characterised by thin, transparent, smooth or finely granular walls as exemplified by *G. polypodioides* (fig. 49) and *G. cryptocarpa* (fig. 50).

Matoniaceae.

The family is represented by 3 living species, of which *Matonia pectinata* has been examined. In this species the spores are sub-triangular, $60\,\mu$ in diameter with a well-defined wall about $5\,\mu$ in thickness and having a finely granular surface (fig. 51).

Hymenophyllaceae.

The family includes two large genera, *Hymenophyllum* and *Trichomanes*, each having about 230 species.

The family is widely distributed throughout the tropics, chiefly in moist and shaded situations. Forrest Shreve (1911) reports that some forms can live as submerged aquatics, while others are capable of growing under relatively dry conditions through possession of an intracellular xerophily similar in kind to Mosses and Selaginellas.

Various fossils have been described under the name *Hymenophyllites*, but Seward (1910) concludes that "there is no evidence which can be adduced in favour of regarding the *Hymenophyllaceae* as ferns of great antiquity, which played a prominent part in the floras of the past." Nevertheless they bear some morphological and anatomical characters in common with certain *Botryopterideae*, and these resemblances point to a remote ancestry for certain features retained by existing members of the *Hymenophyllaceae*. In general, the

family may be regarded as relatively primitive, showing various degrees of specialisation in relation to a hygrophilous habit.

Of the genus *Hymenophyllum* 58 species have been examined. The spores, which in different species range from 25 μ to 90 μ in diameter, are round to sub-triangular, with the exception of *H. tunbridgense* (fig. 52) where the spore is bilateral and somewhat heavily ornamented. In the remaining species examined the wall is thin and transparent and the sculpturing where present is relatively delicate. The smooth type of spore is represented by *H. myriocarpum*, while in *H. denticulatum* (fig. 53) the wall is finely granular. Of more common occurrence are the spinose and spinulose types such as *H. Osmundoides* (fig. 54), while in *H. dejectum* (fig. 55) and *H. tunbridgense* (fig. 52) the tuberculate form is represented. More rarely, a finely pitted variety occurs as seen in *H. lineare* (fig. 56). Thus there is considerable variation in spore ornamentation within the genus, but in general it is delicate, and the most noteworthy feature is the prevailingly thin, transparent wall. The same general features characterise the spores of *Trichomanes*, in which, however, spore size is smaller, varying from 25 μ to 35 μ in the majority of species, although in *T. lucens* (fig. 57) the spore averages about 65 μ in diameter. In this species the wall surface is unusually rough, but the common form of ornamentation is of the spinose type as illustrated by *T. pedicellatum* (fig. 58) and *T. brachyblastos* (fig. 59).

Loxsomaceae.

The family includes two genera, the monotypic *Loxsoma* and *Loxsomopsis*, represented by three living species. *Loxsoma Cunninghami* and *Loxsomopsis notabilis* have been examined. These ferns take a place intermediate in position between the Simplices and Gradatae, and appear to have relationship with the *Hymenophyllaceae* and the *Dicksoniaceae* and, in certain characters, with the *Schizeaceae*.

The spores of *Loxsoma Cunninghami* are tetrahedral and about 75 μ in diameter. The ornamentation of the relatively thick wall, as shown in fig. 48, is unusual and is due to the irregular pitting which gives the surface an unevenly punctured appearance.

The spores of *Loxsomopsis notabilis* are smaller than those of *Loxsoma*, being about 50 μ in diameter with a wall 3 μ thick. The surface is rough but without the pitting so distinctive of *Loxsoma*.

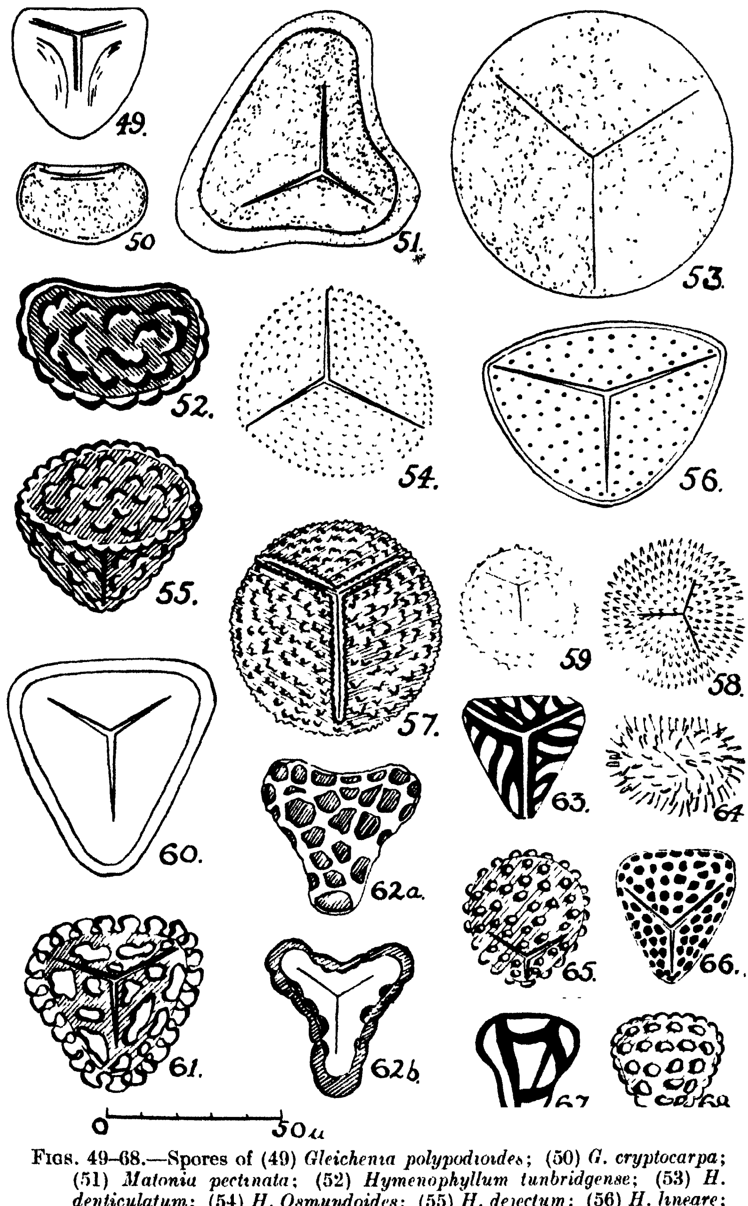
Dicksoniaceae.

The sub-family *Thyrsopterideae* is represented by a single species, *Thyrsopteris elegans*, endemic to Juan Fernandez; its isolation suggests that it is an ancient survival, and several authors have shown that ferns of this type existed in Jurassic times. The spores are 55 μ in diameter, tetrahedral in form and possess a smooth transparent wall 3 μ in thickness (fig. 60).

The sub-family *Dicksonieae* includes *Balantium*, *Dicksonia*, and *Cibotium*, all of which are relatively small genera. In three species of *Balantium* examined the spores are tetrahedral, measuring 45 μ to 50 μ in diameter. In *B. coniifolium* and *B. culcita* the spore wall is finely granular, differing little except in size from *Lycopodium ceylanicum* (fig. 9), while in *B. Copelandi* (fig. 61) the wall is furnished with stout club-shaped processes 3 μ to 5 μ in diameter and 3 μ in length. In *Cibotium* also the spores are tetrahedral, but are generally larger than in *Balantium*, ranging from 50 μ to 75 μ. In some species the wall is smooth, and the structure of the spore closely resembles *Thyrsopteris elegans* (fig. 60); in others the wall is faintly granular as in *B. coniifolium*.

The genus *Dicksonia*, of which there are 17 species, shows greater variation in spore morphology. The spores vary from 35 μ to 75 μ in different species, and while some are smooth or finely granular, the majority show irregular and coarse pitting as seen in *D. lanata* (fig. 62). A characteristic feature is the restriction of the pits to the abapical surface of the spore (fig. 62 *a*). Only in *D. Youngiae* (fig. 63) has the striated type of spore been observed within the genus, recalling *Aneimia*, but differing from it in the radial arrangement of the ridges.

To the sub-family *Dennstaedtiinae* have been referred the genera *Dennstaedtia*, *Microlepia*, *Leptolepia*, *Saccoloma* and *Hypolepis*. The largest genus, *Dennstaedtia*, comprises 57 species, of which 22 have been examined. The spores throughout are tetrahedral with the exception of *D. moluccana*, in



FIGS. 49–68.—Spores of (49) *Gleichenia polypodioides*; (50) *G. cryptocarpa*; (51) *Matonia pectinata*; (52) *Hymenophyllum tunbridgense*; (53) *H. denticulatum*; (54) *H. Osmundoides*; (55) *H. dejectum*; (56) *H. lineare*; (57) *Trichomanes lucens*; (58) *T. pedicellatum*; (59) *T. brachyblastos*; (60) *Thyrsopteris elegans*; (61) *Balantium Copelandi*; (62 *a*) *Dicksonia lanata*, abapical surface; (62 *b*) apical surface; (63) *D. Youngiae*, (64) *Dennstaedtia moluccana*; (65) *D. appendiculata*; (66) *D. samoensis*; (67) *Microlepia tenera*; (68) *Leptolepia novae-zelandiae*. All ×500.

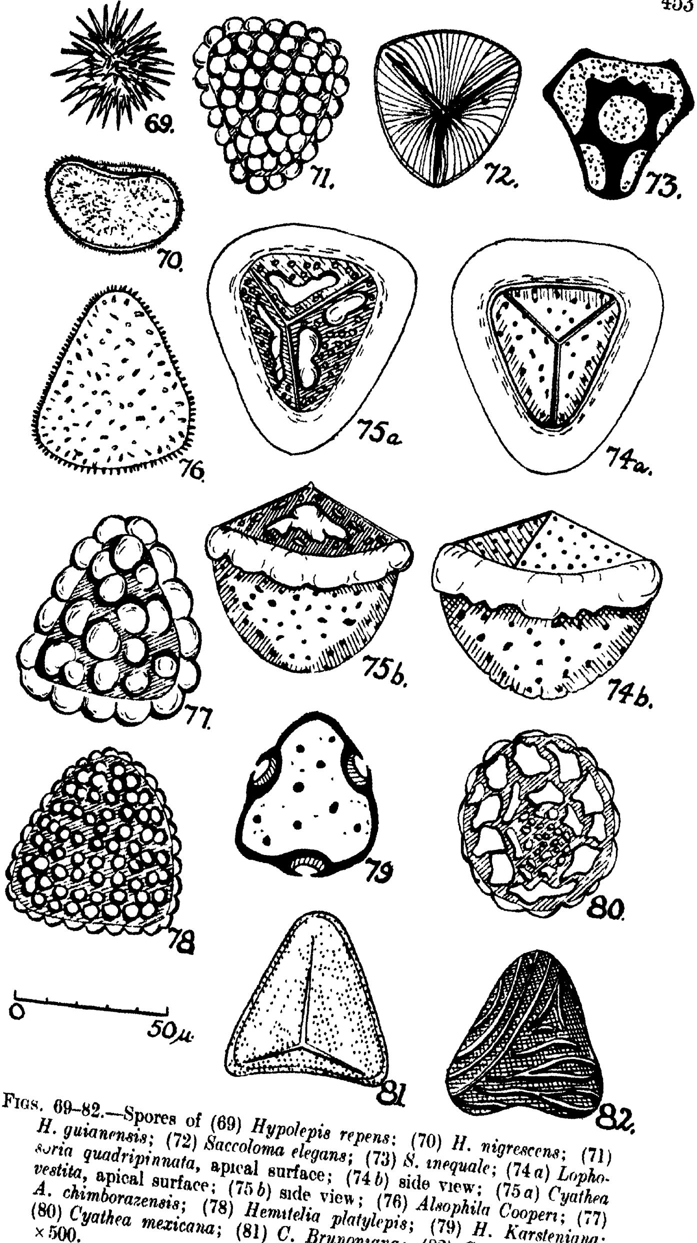
which they are bilateral (fig. 64). They are relatively small, varying from 30 μ to 40 μ, and, as in *Dicksonia*, the architecture of the wall exhibits considerable variation. Smooth and granular forms are found in some species, while the tuberculate type is seen in *D. appendiculata* (fig. 65). Irregular pitting occurs in *D. samoensis* (fig. 66), and in *D. cicutaria* a curious indifferent banding produces an asymmetrical pattern seen also in *Microlepia tenera* (fig. 67). The spores of *D. moluccana* (fig. 64) differ from those of the other species not only in their bilateral shape but also in the presence of numerous spicules, a feature more characteristic of *Hypolepis*.

In the genus *Microlepia*, of which 16 of the 29 species have been examined, the spores are small, ranging from 25 μ to 40 μ. They are generally tetrahedral, clear and transparent, with smooth or slightly granular walls. In *M. Wilfordii*, however, the spore is tuberculate, resembling that of *Dennstaedtia appendiculata* (fig. 65), while in *M. tenera* (fig. 67) the spore wall is irregularly banded. Two species, *M. gymnocarpa* and *M. hirsuta*, deviate from the usual form in having bilateral spores with finely punctate walls.

Of the two species of *Leptolepia*, only *L. novae-zelandiae* (fig. 68) has been examined. The small tetrahedral spores are 30 μ in diameter and the wall is rough and caruneulate, the excrescences being more irregular in outline than in the typical tuberculate spore.

Hypolepis includes 29 species, and among the 18 examined both bilateral and tetrahedral spores are found, the former being the more prevalent. The spore size is again relatively small, and the commonest form of ornamentation appears as prominent spicules, well exemplified in *H. repens* (fig. 69). In *H. nigrescens* (fig. 70), however, the outgrowths of the wall are exceedingly delicate, while, in contrast to this, the emergences in *H. tenerifrons* are short and club-shaped. A further elaboration is seen in *H. guianensis* (fig. 71) where the wall surface is covered with large rounded elevations.

In the genus *Saccoloma* 5 of the 8 species have been examined, and for so small a genus a surprising variety of spore architecture is found. The spores are small and tetrahedral and two of the species have a granular surface. In *S. elegans* (fig. 72) and *S. moluccanum* the wall is marked by fine striations radiating from the apex of the spore, resulting in an



FIGS. 69–82.—Spores of (69) *Hypolepis repens*; (70) *H. nigrescens*; (71) *H. guianensis*; (72) *Saccoloma elegans*; (73) *S. inequale*; (74 *a*) *Lophosoria quadripinnata*, apical surface; (74 *b*) side view; (75 *a*) *Cyathea vestita*, apical surface; (75 *b*) side view; (76) *Alsophila Cooperi*; (77) *A. chimborazensis*; (78) *Hemitelia platylepis*; (79) *H. Karsteniana*; (80) *Cyathea mexicana*; (81) *C. Brunoniana*; (82) *C. decipiens*. All ×500.

ornamentation which appears to be exceedingly rare among living ferns. A different effect is produced in *S. inequale* (fig. 73), where the wall is locally banded to form a thickened circular area from which extensions may pass to the margin of the spore, the corners of which are also conspicuously thickened.

From the foregoing account it will be seen that the family *Dicksoniaceae* exhibits a wide range of spore architecture. All the more usual types, such as the smooth, spinose and tuberculate which are met with in other families, are represented, but there are also those rarer forms with indifferent banding or with fine striations, to which attention has been directed. It is worthy of note also that in this family spores having uniform pitting or regular reticulation of the wall are apparently of rare occurrence.

Plagiogyraceae.

The only genus *Plagiogyra* comprises 11 species of which 9 have been examined. The spores are tetrahedral and uniformly small, ranging in size from 35 μ to 50 μ. Ornamentation is practically absent, the spores being characterised by transparent, smooth or faintly granular walls and are not dissimilar from some of the types seen in *Hymenophyllaceae* and *Gleicheniaceae.*

Protocyatheaceae.

Two monotypic genera, *Lophosoria* and *Metaxya*, are referred to this family which is held to be relatively primitive. It shares certain characters with the *Gleicheniaceae* and the *Cyatheaceae*, and in earlier classification the species were referred to the genus *Alsophila.*

The spores of *Lophosoria quadripinnata* which measure about 55 μ in diameter are of peculiar form. In apical view they are sub-tetrahedral with well-marked tri-radiate crest, but viewed from the side the whole spore appears somewhat compressed (fig. 74). Both upper and lower surfaces are irregularly pitted, and the margin of the spore is expanded to form a projecting annular band about 10 μ across. This type of spore having an annular extension of the wall is apparently uncommon and has to be distinguished from the winglike outgrowths observed in some spores of *Selaginella.* The

feature seen in *Lophosoria* is repeated in the spores of *Cyathea vestita* (fig. 75), although here the ornamentation is different.

The spores of *Metaxya rostrata* bear no resemblance to those of *Lophosoria*, being thin-walled, transparent tetrahedra varying from 35 μ to 50 μ in diameter. The wall is smooth and the general appearance of the spore is not unlike that of *Selaginella Menziesii* (fig. 10).

Cyatheaceae.

The family as now defined includes three genera, *Alsophila*, *Hemitelia* and *Cyathea*. Of the 185 species referred to *Alsophila* 65 have been examined, and among these spore size ranges from 25 μ to 75 μ, though the majority measure 30 μ to 40 μ in diameter. The spores are tetrahedral with relatively thick walls, but nevertheless they remain clear and transparent, recalling the condition in the *Hymenophyllaceae*. The ornamentation is likewise delicate, more than half the species having spores which are smooth or faintly granular as in *A. Sprucei* which, apart from size, is very similar to *Matonia pectinata* (fig. 51). In a few species the spore wall is furnished with short spicules as in *A. Cooperi* (fig. 76), while *A. chimborazensis* (fig. 77) is remarkable for the size of the rounded bosses which decorate the wall, resulting in an unusually coarse tuberculate appearance.

In the genus *Hemitelia* the spores are tetrahedral, ranging in size from 25 μ to 50 μ, and their general characters agree with those of *Alsophila*. In *H. platylepis* (fig. 78) and *H. Smithii* the wall is tuberculate, but the protuberances are smaller and more crowded than in the case of *A. chimborazensis*. Four species have been seen, however, where the spore exhibits a unique structure not met with among any other ferns examined. Its features are illustrated in fig. 79 which shows the spore of *H. Karsteniana* viewed from the abapical side. The wall is thin and transparent and on each face of the tetrahedron it bears a lenticular depression about 10 μ in diameter. The surface is otherwise marked only by a few irregular pits.

The large genus *Cyathea* includes over 180 species of which 62 have been examined. Both tetrahedral and spherical spores occur, ranging in size from 25 μ to 60 μ. As in the two

other genera of the family the spores of *Cyathea* are transparent and, in most species, smooth or faintly granular. The tuberculate type is seen, however, in *C. pilosa* and is almost indistinguishable from the spore of *Hemitelia platylepis* (fig. 78), while in *C. mexicana* (fig. 80), in which the spore is spherical, the ornamentation consists of irregular excrescences of varying size. Minutely pitted tetrahedral spores are seen in *C. Brunoniana* (fig. 81), the spinose type in *C. propinqua*, while the striated form is exemplified by *C. decipiens* (fig. 82) where, however, the striations are not symmetrically arranged as in *Schizaea*. Reference has already been made to the peculiar form of *C. vestita* (fig. 75) in which an annular extension of the wall is developed as in *Lophosoria* (fig. 74).

Dipteridaceae.

Five species all referred to the genus *Dipteris* are placed in this family whose affinities appear to be with the *Matoniaceae*. Of four species examined the spores prove to be uniformly small and bilateral with thin, smooth, transparent walls. They resemble closely the smooth-walled, bilateral spores of some species of *Gleichenia*.

Carboniferous Fossil Spores.

It has long been known that in certain coal seams, particularly in the dull bands, large numbers of spore exines occur, but only in recent years has any attempt been made to use spores as a means of correlation.

Thiessen and his co-workers (1924, 1931, 1932) in America and Lange (1927) in Silesia recognised many spores, mainly megaspores, as characteristic of particular seams, and these authors were among the first to suggest the use of such microfossils as a basis of correlation. Their method was to make a microscopic examination of a series of thin sections of a seam from floor to roof, classify the spores according to size, shape and ornamentation, and record their relative frequency. Slater (1930, 1931) and other workers in England have also employed this method, but its practical usefulness is more or less restricted to megaspores, since the small size of the microspores renders difficult any appreciation of the characteristic differences in ornamentation of the wall when

seen in section. The possible use of microspores for identification of individual seams was first examined in England by Raistrick (1933, 1934), though the method he adopted had been used previously in Germany and elsewhere. A description of the process by which the microspores are separated is given in Raistrick's (1934) paper. It consists essentially of maceration and chemical treatment which removes the humified material, leaving the resistant parts free of the matrix, thus enabling spores to be viewed entire, when size, shape and pattern become clearly visible.

For purposes of correlation of coal seams the included spores have been classified in an entirely arbitrary fashion, the grouping being based on the thickness and ornamentation of the wall, together with any other outstanding feature. The spore types have thus been arranged by Raistrick (1933, 1934, 1938) in seven groups, designated A, B, C, etc., and the several varieties within each group assigned a number, A1, A2, etc.

In this artificial arrangement, Group A, of which figs. 83 to 85 are examples, includes spores with a clear centre surrounded by a thick ring, frequently dark brown in colour and measuring $\frac{1}{3}$ to $\frac{1}{5}$ of the total diameter of the spore.

In Group B (figs. 86 to 89) the spores are thin-walled and transparent, generally without surface markings.

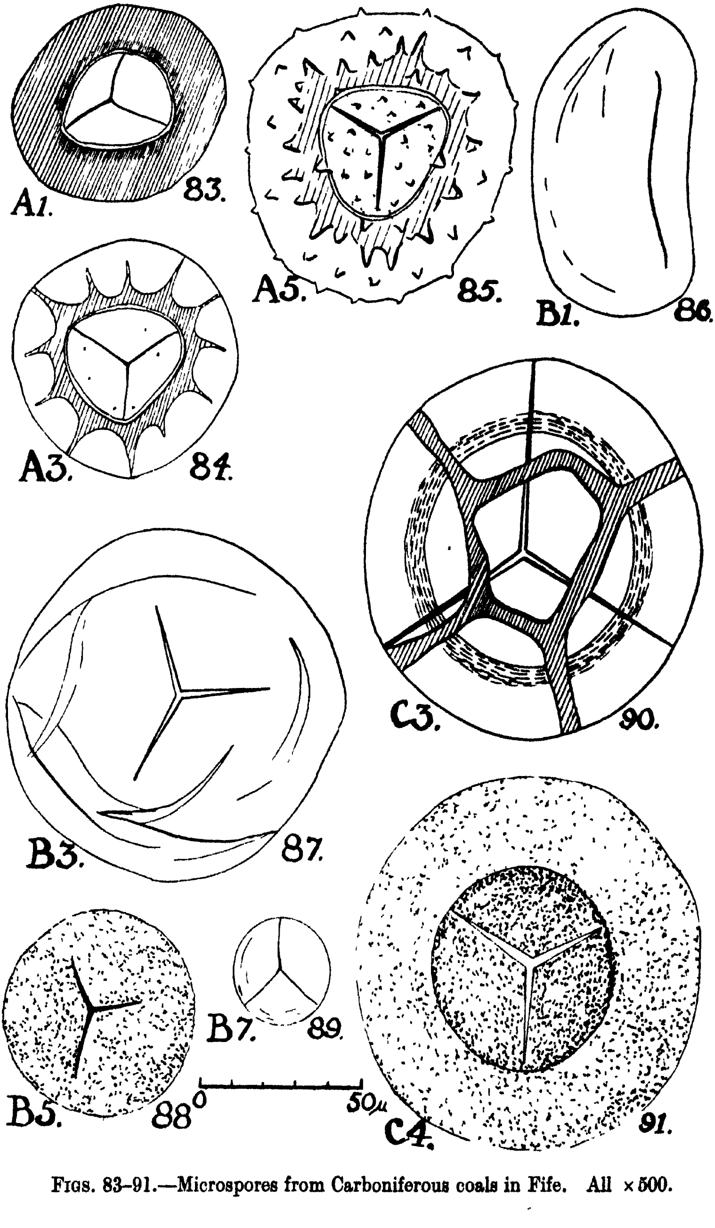
Group C (figs. 90 and 91) includes large spores (70 μ to 100 μ in diameter) described as showing central and concentric structure.

In Group D (figs. 92 to 102) the spores are generally triangular or sub-triangular with a well-defined tri-radiate slit and with various surface ornamentations.

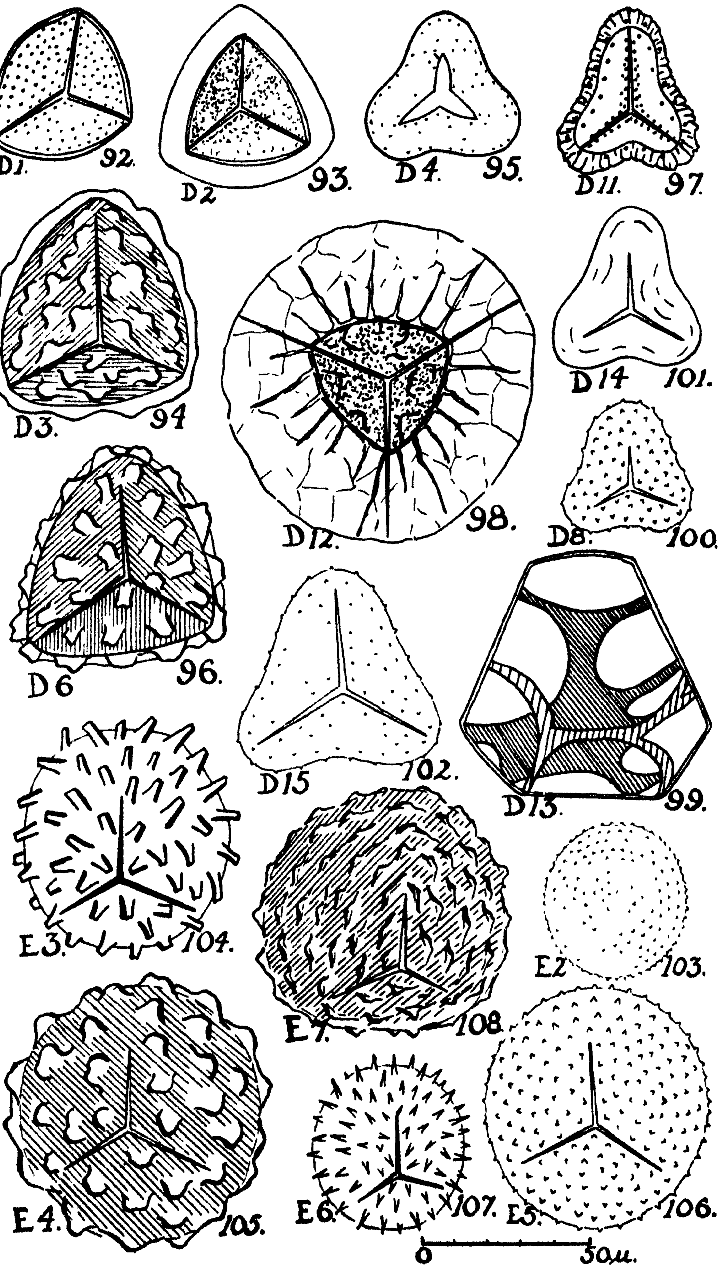
Group E (figs. 103 to 110) comprises round spores with a moderately thick wall furnished with spinose or tuberculate outgrowths.

In Group F (figs. 111 to 113) the spores have reticulate markings, while Group G (fig. 114), consisting so far of one example, is an oval type with fine irregular ridges covering the surface.

According to this scheme, therefore, the rich variety of Carboniferous spores is reduced to a relatively simple basis for purposes of comparison, but it is highly improbable that such an artificial grouping provides any expression of affinity.



Figs. 83–91.—Microspores from Carboniferous coals in Fife. All ×500.



FIGS. 92–108.—Microspores from Carboniferous coals in Fife. All ×500.

From the present survey of spores of existing but nevertheless relatively primitive Pteridophytes, it is evident that markedly different types recur in widely separated families, and the observation by Seward (1931) regarding the seeds of Palaeozoic Pteridosperms that " in the course of ages similar results have been achieved by many diverse groups of plants; age after age there has been a repetition of unconscious effort towards the same end," could equally well be applied to microspores. Nevertheless, it is of considerable interest that fairly close comparisons may be drawn between the fossil forms and modern types.

Within the A group, for example, the thick ring of A1 resembles that of *Cyathea vestita* and *Lophosoria quadripinnata* (figs. 83, 75, and 74), whereas A3, with its equatorial ring, suggests *Selaginella rupestris* (figs. 84 and 24).

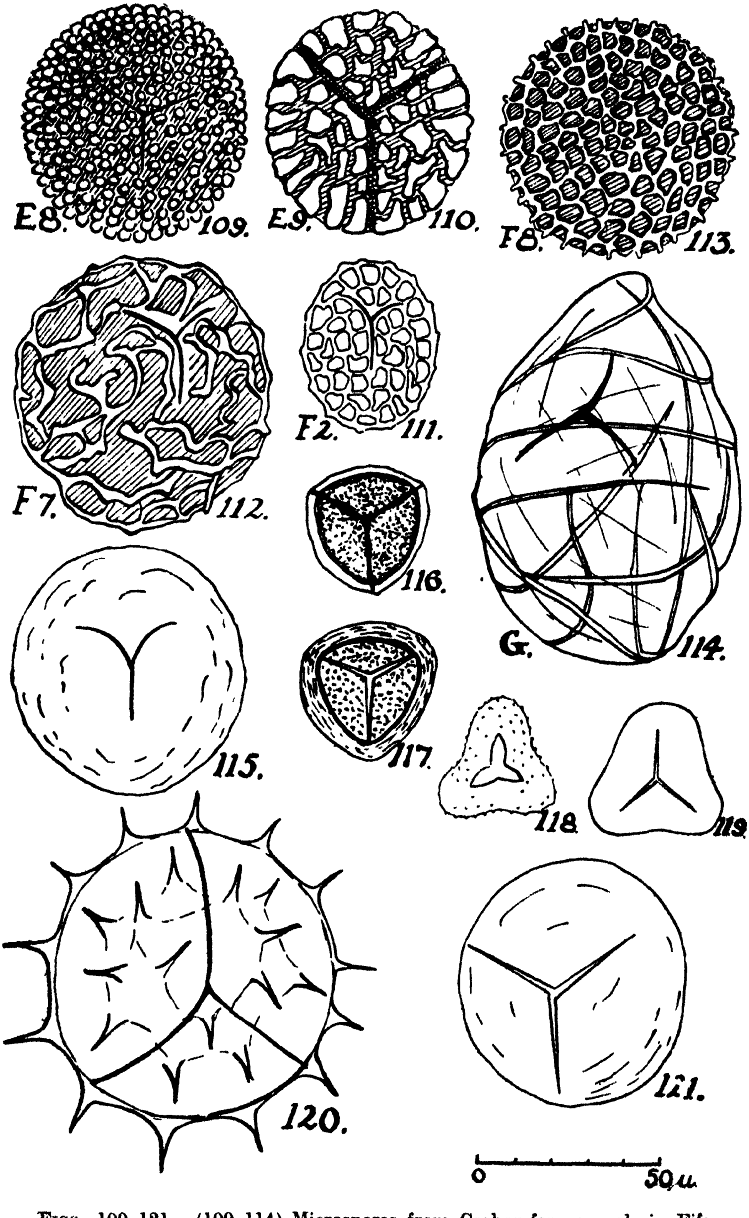
Of the B type the range in size is continuous from 15 μ to 100 μ and it seems likely that this group is a very heterogeneous one, embracing types which are common to almost every family among recent Pteridophytes, and, in all probability, equally common in Palaeozoic time. Further, it has been observed, both in recent and fossil spores, that ornamentation appears late during development. When immature, the spore wall is smooth; thus some of the spores included within Group B may possibly be immature specimens of the E type.

The C type, with concentric structure, has not been observed among the recent Pteridophytes examined, but in both the D and E groups, where great variety in architecture is admitted, numerous comparisons may be made with living representatives. Among the more noteworthy resemblances may be mentioned the winged type of D12 and *Selaginella megastachya* and *S. rupestris* (figs. 98, 24, and 25); the peculiar D13 and *Microlepia tenera* (figs. 99 and 67); the "stachelformig" E3 and *Selaginella spinosa* (figs. 104 and 22); the spinulose E5 and *Hymenophyllum Osmundoides* (figs. 106 and 54); the spinose E6 and *Selaginella xiphophylla* (figs. 107 and 14); E7 and *Trichomanes lucens* (figs. 108 and 57); the tuberculate form of E8 and *Selaginella chrysocaulos* (figs. 109 and 16); and E9 and *Cyathea mexicana* (figs. 110 and 80).

Recent examples of the reticulate F type of spore occur commonly among the Lycopods and *Ophioglossaceae*, and comparisons could be drawn between F8 and *Ophioglossum*

pedunculosum (figs. 113 and 30) and F7 and *Helminthostachys zeylanica* (figs. 112 and 32).

While such comparisons are possible, it should be noted that the Palaeozoic spores are generally larger than recent forms, and it is not suggested that the examples given are in any way specific or even generic equivalents, but they illustrate the existence in the Palaeozoic period of spore types which have persisted among Vascular Cryptogams to the present day. Moreover, there is considerable probability that some of the fossil spores may have belonged to Bryophytes, for as Walton (1925, 1928) has clearly demonstrated the group was represented in the Coal Measures. In a recent paper by Wigglesworth (1937) on South African species of *Riella*, two spores are figured and described, one of which is very similar to E3 (fig. 104) and the other closely resembles A5 (fig. 85). Again, reticulate ornamentation of the spore is not uncommon among Liverworts, being known in *Riccia* and *Fossombronia*, while the spinose type occurs in *Anthoceros*. Pteridosperms also have contributed largely to the material of the coal seams, and to this group many of the spores belong which have been described and figured by Kidston (1923), Halle (1933), Florin (1937) and others. Those examples which have been definitely assigned to their parent plant can be readily referred to one or other of the artificial groups. Thus *Crossotheca Hughesiana* and *C. Hoeninghausi* figured by Kidston (1923), and *Aulacotheca elongata* and *Telangium bifidum* figured by Florin (1937), would be classed with the B group on account of their thin wall and indifferent sculpturing. Likewise, the Calamarian spores *Asterophyllites equisetiformis*, *Calamostachys Binneyana* (fig. 115) and the spore of *Cheirostrobus pettycurensis* (fig. 121) would fall into the same group. According to Hartung (1933) the spores of *Calamariaceae* are transparent, thin-walled and without sculpturing or only very occasionally finely punctate; the size ranges from 70 μ to 130 μ, and the thin-walled nature of the spores renders them liable to folding and wrinkling during fossilisation, the original spherical form becoming distorted. The tri-radiate mark is characteristic and may be thin and hair-like or thick, with radii $\frac{1}{2}$ to $\frac{1}{3}$ of the spore diameter. These features are all evident in the spore B3 (fig. 87) which is very probably of Calamarian affinity. The same globose form with thin wall and absence of



FIGS. 109–121.—(109–114) Microspores from Carboniferous coals in Fife. Spores of (115) *Calamostachys Binneyana*; (116) *Lepidostrobus Jacksoni*; (117) *L. oldhamius*; (118) *Renaultia gracilis*; (119) *Boweria minor*; (120) *Sphenophyllum Dawsoni*; (121) *Cheirostrobus pettycurensis*. All ×500.

ornamentation is characteristic of recent Equisetales (fig. 3), though in the latter there is the unusual development of elaters and no trace of the tri-radiate mark. At what period these elaters first appeared is unknown. In spores of *Equisetum* described by Halle (1908) from the Rhaetic and Lias, however, the tri-radiate mark is present and elaters are still absent.

To the D group may be referred the spores of *Lepidostrobus Jacksoni* (fig. 116) and *Lepidostrobus oldhamius* (fig. 117) which resemble D1 and D2 respectively. The small triangular spore of the Pteridospermic *Renaultia gracilis* (fig. 118) with its open tri-radiate slit may be compared with D4 or D8 (figs. 95 and 100), and that of *Boweria minor* (fig. 119) with D14 (fig. 101). The large spore of *Sphenophyllum Dawsoni* (fig. 120) would fall into the E group, though no equivalent has so far been met with among spores of Carboniferous coals.

In a recent paper Paget (1936) has attempted to refer each of the artificial groups to a particular plant phyllum. This author regards the A group as equivalent to Equisetales, the B group to the Lycopodiales, the D group to the Pteridosperms and the E group to the Sphenophyllales. This arrangement is wholly inconsistent with the knowledge we have of those fossil spores which have so far been definitely identified, and where such an arbitrary classification is concerned each group must indubitably include representatives of many different families. Considering the multiplicity of species in the Carboniferous alone, much careful work still remains to be done before the great variety of spores found in coals can be assigned, even approximately, to their respective families. Meanwhile, Potonié and his co-workers (1932) have adopted a system of binomial nomenclature in which the generic name of *Sporonites* is used both for micro- and megaspores.

Within the last decade many workers in different parts of the world have been studying the spores preserved in coal, and numerous types have been described and illustrated by Elovski (1930), Ergolskaia (1930), Potonié (1932), Raistrick (1934), Berry (1937) and others. Similar, if not identical, types have been recognised in Scottish coals, and it is hoped to give a detailed account of these in a subsequent paper.

Summary and Conclusions.

In the foregoing pages an account is given of the general morphology of the spore in the more primitive families of living Pteridophytes with a view to comparing them with the various types of spore which occur, sometimes in great abundance, in coals of Carboniferous age. In the families examined the tetrahedral type of spore seems to be prevalent, and this is probably the primitive type for Pteridophytes, although the *Psilotaceae*, generally recognised as a primitive family, are characterised by the possession of bilateral spores. Yet *Rhynia* and *Hornea* have tetrahedral spores. With few exceptions there is little evidence that the more detailed features of spore architecture remain constant within the limits of a family, and even for genera there are not many examples where spore characters could be held to be diagnostic. Attention may be directed, however, to *Equisetum*, *Lycopodium*, *Isoetes*, *Marattia*, *Osmunda* and *Schizaeaceae*, where some degree of constancy in spore shape and ornamentation may be observed. On the other hand, in the large genus *Selaginella*, and in most of the families of Filicales reported upon, a wide range in spore form and pattern is met with. A considerable number of the spores occurring in coals can be fairly closely compared with modern forms, more especially with those of the really primitive families; but although resemblances occur it would be rash in the present state of our knowledge to suggest identity.

The prevalent types of spores found in coals are briefly described and an artificial classification is outlined. The fossil spores are generally larger than those of modern plants and some have been noticed which differ markedly from existing forms. This is not surprising having regard to the wealth of vegetation during Carboniferous times, and although some of the spores are doubtless pteridophytic, it is not improbable that many are of bryophytic or pteridospermic affinity. Before their exact relationships can be established with any degree of certainty much detailed work on the spores both of ancient and living plants remains to be done.

ACKNOWLEDGMENTS.

I have to express my indebtedness to Sir William Wright Smith for generously supplying the large amount of material which has made this investigation possible, and to Professor J. R. Matthews for having suggested the problem and for much help and advice during its progress. To Professor J. Walton I owe thanks for permission to examine the extensive collection of fossil slides in his Department. For facilities to carry out the work in the Geological Department of the University of Edinburgh I am indebted to Professor T. J. Jehu. The investigation has been conducted with the aid of a grant from the Carnegie Trust, to whom I have also to express my thanks for financial assistance towards the cost of illustration of this paper.

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THE SCOTTISH ALPINE BOTANICAL CLUB EXCURSION, 1937. By ROBERT MOYES ADAM, F.L.S. (With Pls. XXXIV–XXXVI.)

The Club visit took place on 20th July, and the occasion was ushered in by gloomy and threatening skies.

The mountains visited are known as the "Grey Corries," and lie between Glen Spean and Glen Nevis. The group comprises several summits which rise above 3000 feet. Stob Coire an Easain was the peak round which interest was centred.

The main purpose of the excursion was to report on the arctic alpine species *Saxifraga caespitosa*, now an exceedingly rare plant in Scotland, where it occurs in only two localities in widely separated districts of the Grampian Range.

At one of these, which is in a corrie of Beinn a Bhourd in the Eastern Cairngorm, the Club made an unsuccessful search some years ago. The decision was therefore made to visit the alternative habitat in Lochaber discovered by the Club in the summer of 1887, when, under the leadership of the late Dr. Stuart of Chirnside, the Saxifrage was found in considerable abundance.

Spean Bridge, as the base of operations, was chosen in preference to Fort William, which had been the former rendezvous for this district.

To secure facilities for exploring the hills application was made to the proprietors, the British Aluminium Company, who recently made the purchase from Lord Abinger in the interests of their hydro-electric power scheme. The Club's request was readily granted, with an offer of assistance if such was required.

Quartzite is a dominant feature of the rocks of this region, although schists also enter largely into their composition, associated with altered limestones. The corries themselves are unusually grand, and can rival any in Scotland. Corrie Vassie, which was visited, is no exception, and it has been also termed the "Corrie of the Wolf." This corrie is one of

a group which appears as a conspicuous landmark to the south of Spean Bridge, the burns all draining towards the north into the River Cour.

On the morning of the 20th two heavily laden cars left the hotel in the direction of Leanachan, which was formerly a stalker's house, but is now occupied by a forester employed in the work of the Forestry Commission here. The road ending, cars were parked, and then a march began over the dreary moorland that lay towards the hills. Most of this overlies the bed of the ancient glacier that once occupied the valley, but which now is a water-logged tract with acres of peat covered by rush, sedge, and cotton grass. One stream, the Allt an Loin, had to be forded, and eventually rising ground with drier soils was crossed, and the private tramway line connecting Fort William Aluminium Factory with Loch Treig was reached. This track was followed for upwards of two miles towards the entrance to Corrie Vassie. On reaching the shoulder of Meall Socaĭch the tramway was left, and a course taken up the steep gradient of one of the northern spurs that lead on to Stob Coire an Easain. Halts were frequent on this slope, and attention directed to the plants round about. This hill appeared to have good grazing, a fact that was made evident by a fine herd of red deer which, on getting the scent of the invaders, bounded out of sight beyond the skyline. On the wetter parts of the hill *Parnassia palustris* and *Polygonum viviparum* were abundant.

After reaching the 1500-foot contour the party divided so that more ground might be examined, and notice taken of the general configuration of this valley. Several immense masses of schist, which protrude in the glen, give a boldness to the scene and show remarkable examples of ice-worn surfaces. Through these the stream cuts a deep channel, and tumbles in a series of waterfalls.

Above, a more spacious glen opens out. The slopes of Meall Socaich steepen and become craggy. The schistose nature of its rocks provides a series of small cliffs, with interesting crannies and ledges. The two most interesting alpines seen were *Hieracium alpinum* and *Salix lapponum*. The first-named was so numerous over some of the higher ledges that the place looked yellow, while the willows exhibited fine clusters of female catkins.

As the party neared the heart of the corrie the savage grandeur of the place came into view. A wide amphitheatre encircled by screes of quartzite blocks fell sharply down to end in a litter of huge fragments at the base of the corrie. Across the northern face of one of these stone shoots rose a series of vertical buttresses breached by gullies. These buttresses towered aloft in a spectacular manner suggesting the bastions of a mighty fortress, known to the stalkers as the "Castle."

Upon these rocky ramparts the party decided to concentrate, but before advancing towards them took stock of the possible routes. This precaution was advisable in view of the mists which rose and fell, and at intervals completely obscured the highest parts of the corrie.

The ascent commenced by a very tedious grind up the steep slope, where the loose nature of the stones made care necessary, while the glare from the surface of the quartzite added to the discomfort. Plant life was remarkably scarce, and except for a few tufts of *Juncus trifidus*, which clung precariously to pockets of soil in some of the boulders, no green thing relieved the monotony of the climb. At one point a great bed of hardened snow was encountered.

As the precipices were approached they were seen to consist of horizontal bands of schist into which entered folds of an altered limestone. The latter formed the major element towards the eastern side, and showed its nature in the flaggy bedding of the rock. The whole extent of this exposure was undergoing extreme erosion, and the slope immediately below was covered by slabs recently freed from the cliff. At places the rocks overhung to an alarming degree, and prevented rain from reaching the lower ledges, on which a rich assortment of plant life flourished. This led the party to search with some thoroughness this unusual site. Throughout the time spent rain fell steadily, and it was noted that on the well-stocked ledges conditions remained perfectly dry.

In one of these dry corners the find of the day, *Saxifraga caespitosa*, was made. The first specimen seen was an aged plant in fruit, and not far away another in the same state was found. Three or four young rosettes were also seen, besides a few tiny seedlings, but a diligent search over other parts of the cliff failed to reveal any additional specimen.

It was indeed a meagre total, and one which disappointed the party in view of the reported abundance when this station was last visited by the Club in 1913.

Among the other notable plants seen were *Saxifraga nivalis* and *Cerastium arcticum*, some of the ledges being white with the flowers of the latter. On the damper rocks, and particularly in the gullies, were numerous plants of *Saxifraga rivularis*. Attempts to examine parts of the cliffs had to be abandoned owing to the unstable condition of the rocks, and the party descended to the base of the corrie, where some fine specimens of *Deschampsia alpina* were discovered. Later a deer track by the stream was followed down the glen, where some ice-worn rocks yielded some large patches of *Arctostaphylos alpina* in fruit. Returning by the same route Leanachan was reached without incident, where the hospitality of the forester was extended to the party.

During the remainder of the stay some minor excursions were enjoyed by the Club, and the first took place over the district between Spean Bridge and Loch Arkaig. Proceeding across the River Spean the road towards Gairlochy was followed. This gave an opportunity to see something of the extensive glacial deposits through which the river flows on its westerly course. The gorge carved out by the river is clad with luxuriant vegetation with much deciduous woodland. Splendid specimens of Ash, Sycamore, Rowan, Whitebeam, and Aspen were seen. The embankment which carries the branch railway to Fort Augustus proved attractive, since several interesting species were found in plenty, though not natives of the district.

Between this point and Loch Arkaig interesting examples of land recently afforested were passed. These lay along the shores of Loch Lochy, and were signs of the activity of Lochiel, the proprietor, and the Forestry Commission. At Loch Arkaig time was spent searching some marshland beside the loch. The most striking plant noted was *Habenaria virescens*. It was growing among a grove of Alders in the silt which must frequently be submerged by the waters of the loch.

The "Parallel Roads" of Glen Roy occupied part of a day, and cars were used to convey the party to the head of the Glen at Turret Bridge. The "Roads" were seen to advantage

from the highest part of the route where it skirts Bohuntine Hill. Much of the Glen contains valuable sheep pasture, and at the lower end several crofts dot the landscape. Towards the upper reaches the slopes are heath covered with coarse moorland. Some extensive moraines occur at the watershed, and mark the site of the lake, which drained in Glacial times towards the Spey. Interesting stretches of gravel beside Dalreach Lodge were covered by Thyme and huge patches of *Saxifraga aizoides*. The "Roads" were examined at close quarters, and their nature seen to consist of rounded boulders reminiscent of a "raised beach." Among the pasture *Gymnadenia conopsea* was very abundant, and in parts of the Glen great stretches of bracken appear to be advancing on to the grassland.

The meeting concluded with another visit to Corrie Vassie, when perfect weather enabled some photographs to be taken. The summit of Stob Coire an Easain was visited and a fine panorama seen from the ridge which separates Glen Spean from Glen Nevis.

The following plants were among those noted:—

Thalictrum alpinum Linn.
Cochlearia alpina Wats.
Silene acaulis Linn.
Cerastium arcticum Lange
Hypericum pulchrum Linn.
Geranium sylvaticum Linn.
Sibbaldia procumbens Linn.
Alchemilla alpina Linn.
Saxifraga rivularis Linn.
,, *caespitosa* Linn.
,, *nivalis* Linn.
,, *hypnoides* Linn.
,, *aizoides* Linn.
,, *oppositifolia* Linn.
Parnassia palustris Linn.
Sedum roseum Scop.
Cornus suecica Linn.
Galium boreale Linn.
Solidago cambrica Huds.
Gnaphalium supinum Linn.
Hieracium alpinum Linn.

Vaccinium uliginosum Linn.
Arctostaphylos alpina Spreng.
Pedicularis sylvatica Linn. (white form)
Plantago maritima Linn.
Polygonum viviparum Linn.
Oxyria digyna Hill
Salix lapponum Linn. (♀ flowers)
,, *herbacea* Linn.
Gymnadenia conopsea Br.
Habenaria virescens Zollik.
Tofieldia palustris Huds.
Juncus trifidus Linn.
Carex leporina Linn.
,, *curta* Good.
,, *panicea* Linn.
,, *Oederi* Retz.
,, *binervis* Sm.
,, *pulla* Good.
Deschampsia alpina Roem. et Schult.
Festuca ovina Linn. *vivipara*
Asplenium viride Huds.
Lastrea aristata Rendle et Britten v. *alpina* Moore
Athyrium alpestre Milde
Lycopodium alpinum Linn.

Coire Vassie Cliffs formed by bands of schist and limestone and screes of quartzite.

R. M. Adam.

Habitat of *Saxifraga caespitosa* Overhanging slabs of altered limestone

R. M. Adam

Saxifraga caespitosa Plant in fruit in a cranny of the limestone.

R M Adam.

Report of the Annual Conference of the Cryptogamic Section, 1938.

By Rupert Smith.

(Read 20th October 1938.)

The Fifty-seventh Annual Conference of the Cryptogamic Section of the Society was held at Aviemore from 5th to 9th September.

Kelso had originally been selected, but a change was made in order to have the advantage of meeting the British Mycological Society, several of our members belonging to both societies.

The hall of the British Legion had been secured as headquarters, where specimens were exhibited and evening meetings held. Most of the party having arrived on Monday, 5th September, a start was made in the birch wood at the base of the hill called Craigellachie, and also in the grounds of the Aviemore Hotel. In the former locality a *Cortinarius* (*Dermocybe*) *lepidopus* was plentiful, and in the latter locality *Spathularia clavata* (a Discomycete) was found.

Tuesday, 6th September, was devoted to the forest of Rothiemurchus, in the neighbourhood of Loch an Eilean. On Wednesday, 7th September, the party worked the ground towards the Coylumbridge end of the forest, and on Thursday, 8th September, the party went to Abernethy forest, near Boat of Garten. The moor around Boat of Garten is covered with *Vaccinium Vitis-Idaea*, *Arctostaphylos Uva-Ursi*, and *Empetrum nigrum*, but little fruit was seen.

There was a fair gathering of fungi in the vicinity of Garten loch.

A visit to the woods north of Aviemore as far as Loch Vaa was fixed for Friday 9th. Nothing of importance was obtained near Loch Vaa, but *Lobelia dortmanna* was in evidence in the shallow part of the loch and a few racemes were still in flower. The large forest to the west of Loch Vaa yielded a nice variety of *Cortinarii*, and a large patch of the Pyrenomycete *Cordyceps ophioglossoides* parasitic on *Elaphomyces granulatus*.

Besides the foregoing forays, detached parties visited the two golf courses and the woods adjoining. In one, quite a quantity of *Gomphidii* and *Cortinarius mucosus* was seen. The weather throughout was unfavourable, being dull, showery, and rather cold for the season. The district is noted for the large variety of fungi, and especially for Hydnums; but the results did not equal what was collected during the 1927 visit. Possibly the cold summer affected the development.

In those forests it was satisfactory to find so little of the depredations of the parasitic fungi; very few specimens of *Fomes annosus* or *Armillaria mellea* were observed. It was remarkable that what is considered the commonest of the larger fungi, *Hypholoma fasciculare*, was almost absent.

Kelso was arranged for the Fifty-eighth Conference in 1939.

LIST OF SPECIES GATHERED DURING THE FORAY.

(Arranged according to "British Basidiomycetae" by Carleton Rea.)

HYMENOMYCETES.

Pluteus	cervinus.
Lepiota	amianthina, procera.
Psaliota	arvensis, sylvicola.
Anellaria	separata
Amanitopsis	vaginata.
Amanita	mappa, phalloides, phalloides var. verna, muscaria, rubescens, porphyria.
Armillaria	mellea, robusta.
Pholiota	mutabilis, subsquarrosa, spectabilis, flammans.
Stropharia	semiglobata
Cortinarius	(Phlegmacium) crassus, sebaceus, caesiocyaneus.
	(Myxacium) mucosus, elatior, vibratilis.
	(Inoloma) violaceus, tophaceus.
	(Dermocybe) tabularis, caninus, anomalus, lepidopus, phoeniceus, semisanguineus, anthracinus, cinnamomeus.
	(Telemonia) armillatus, hinnuleus, gentilis, brunneus.
	(Hydrocybe) decipiens.
Inocybe	rimosa, geophylla, lacera, Cookei, fastigiata.
Astrosporina	praetervisa, languinosa, scabella.
Tricholoma	fulvum, albobrunneum, rutilans, decorum, columbetta, imbricatum, murinaceum, saponaceum, virgatum, carneum, melaleucum.
Entoloma	clypeatum, rhodopolium, sericeum.
Hebeloma	crustuliniforme.

Hypholoma	capnoides, fasciculare.
Clitocybe	clavipes, aurantiaca, odora, infundibuliformis, cyathiformis, fragrans.
Laccaria	laccata.
Hygrophorus	pratensis, laetus, ceraceus, coccineus, miniatus, Reai, micaceus, puniceus, conicus, psittacinus.
Clitopilus	prunulus.
Flammula	carbonaria, astragalina, hybrida, sapinea.
Gomphidius	glutinosus, roseus, viscidus, gracilis.
Collybia	radicata, maculata, distorta, butyracea, tuberosa, ocellata.
Leptonia	lampropus, serrulata, sericella, formosa.
Naucoria	semiorbicularis.
Psilocybe	semilanceata.
Panaeolus	sphinctrinus, papilionaceus.
Mycena	atro-marginata, rubo-marginata, rosella, pura, Adonis, polygramma, pullata, metata, ammoniaca, debilis, sanguinolenta, galopus, epipterygia, corticola.
Nolanea	pascua, papillata, cetrata (Fr.) Schroet., icterina.
Galera	tenera, hypnorum.
Psathyrella	gracilis.
Omphalia	striaepilea, sphagnicola, umbellifera, campanella, fibula
Tubaria	furfuracea.
Pleurotus	porrigens.
Crepidotus	mollis.
Russula	nigricans, adusta, lepida, furcata, heterophylla, foetens, ochroleuca, fellea, subfoetens, drimeia, fragilis var. fallax, emetica, atropurpurea, xerampelina, Velenovskyi (M. & Z.), vesca, claroflava (Grove), gracillima (new to Britain).
Lactarius	torminosus, insulsus, blennius, uvidus, vellereus, deliciosus, pallidus, quietus, vietus, rufus, subdulcis.
Coprinus	comatus, atramentarius, plicatilis.
Marasmius	peronatus, hariolorum, dryophilus, foetidus.
Androsaceus	androsaceus.
Panus	torulosus, stipticus.
Lentinus	cochleatus.
Nyctalis	parasitica.
Cantharellus	cibarius, infundibuliformis.
Paxillus	giganteus, involutus, atrotomentosus.
Boletus	luteus, elegans, viscidus, badius, bovinus, piperatus, variegatus, chrysenteron, subtomentosus, edulis, calopus, pinicola, erythropus, duriusculus, versipellis, scaber.

Polyporus	perennis, nummularius, leucomelas, betulinus, amorphus, adustus.
Fomes	fomentarius, annosus.
Polystictus	hirsutus, versicolor, abietinus.
Phlebia	merismoides.
Hydnum	repandum, repandum var. rufescens, imbricatum, melaleucum, compactum, aurantiacum, ferrugineum, auriscalpium.
Ptychogaster	albus.
Stereum	rugosum, hirsutum.
Corticium	sambuci.
Peniophora	sanguinea, hydnoides.
Clavaria	cristata, stricta, fusiformis.
Exobasidium	Vaccinii.
Exidia	saccharina.
Tremellodon	gelatinosum.

GASTEROMYCETES.

Lycoperdon	caelatum, saccatum, depressum, echinatum, umbrinum, velatum, perlatum, pyriforme.
Bovista	nigrescens, plumbea.
Scleroderma	aurantium, verrucosum.

PYRENOMYCETES.

Cordyceps	ophioglossoides (Ehrh.) Link.

DISCOMYCETES.

Spathularia	clavata (Schaeff.).
Geopyxis	carbonaria (A. & S.).
Chlorosplenium	aeruginosum (Oeder).
Mollisia	cinerea (Batsch).
Coryne	sarcoides (Jacq.).
Macropodia	macropus Pers.
Peziza	aurantia Pers.
Tricoscypha	calycina (Schum.).

UREDINEAE.

Gymnosporangium	Juniperi Link.
Melampsporidium	betulinum.
Sclerotinia	Curreyana (Berk.) Karst.

PLECTASCALES.

Elaphomyces	granulatus Fr.

TRANSACTIONS

OF THE

BOTANICAL SOCIETY OF EDINBURGH

SESSION CIII

THE SPORES OF BRYOPHYTA COMPARED WITH THOSE OF CARBONIFEROUS AGE. By ELIZABETH M. KNOX, M.A., B.Sc. (With Pls. XXXVII–XLI).

(Read 20th April 1939.)

INTRODUCTION.

In a previous paper (Knox, 1938) attention was drawn to the general similarity in structure between the spores of many of the modern Pteridophyta and those occurring in coals of Carboniferous age, but at the same time it was pointed out that a large number of the fossil spores might be of bryophytic rather than of pteridophytic origin. In order to test this, a study of the spores of Bryophyta has now been undertaken and the following observations are based upon the examination of about 900 species both British and foreign. It is not intended to deal fully with the minute structure of these spores but to give only a general account of their morphology as was done in the case of the Pteridophyta, in the belief that short descriptions supplemented by illustrations may be useful to geologists and others who, like the author, are engaged upon the study of spores contained in coals.

It is of considerable interest that the Hepatics exhibit a much greater diversity in spore structure than the mosses,

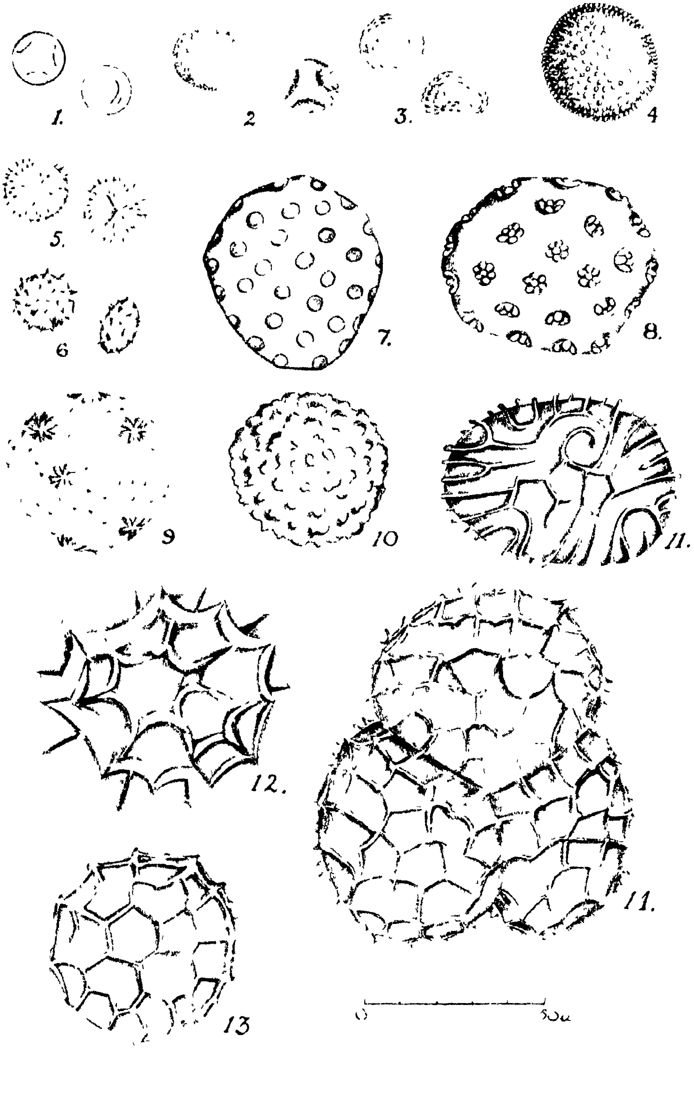
and while the latter may be treated from this point of view as a relatively uniform group, the former will be more conveniently dealt with by following a systematic order, and the sequence here adopted is that of Verdoorn (1932). Before passing to the systematic survey, however, a few general features in the spore morphology of the Hepatics may be mentioned. The spores are invariably of the tetrahedral type, the wedge-shaped form sometimes found in the Pteridophyta being apparently absent. With few exceptions they become separated from the tetrad before the capsule opens, though in most species of *Sphaerocarpus* the spores remain in tetrads. When mature they are commonly spherical but may exhibit flattened ternate faces, thus showing distinct apical and ab-apical surfaces, and any ornamentation which may be present is usually most markedly developed on the ab-apical surface. Within the limits of a single species there is little variation in spore size. A considerable range, however, occurs within a genus, e.g. *Riccia*, and among different genera the range in size is often very great: for example, in *Marsupella Funckii* the spores are only 8 μ, while in *Riccia Gougetiana* they attain a size of 200 μ in diameter. There is also great variety in spore ornamentation and the structural features of the wall are frequently a valuable means of distinguishing between species of the same genus, particularly where the spores are large as in *Fossombronia* and *Riccia*. The heavily ornamented exospore seems to be most highly developed in those species where the spores undergo a period of rest before germination, whereas the thin-walled type germinates almost at once or even before it has been shed from the capsule as in *Pellia epiphylla* and *Conocephalum conicum*.

Further details follow under the several families which are grouped according to Verdoorn's classification in the *Manual of Bryology* published in 1932.

HEPATICAE.

Jungermaniales acrogynae.

In this group representatives of the following families have been examined: *Haplomitriaceae*, *Epigonanthaceae*, *Scapaniaceae*, *Cephaloziellaceae*, *Trigonanthaceae*, *Ptilidiaceae*, *Pleuroziaceae*, *Radulaceae*, *Porellaceae*, *Lejeuneaceae*, *Frullaniaceae*.



Figs 1-14 Spores of (1) *Lophocolea heterophylla*, (2) *Trichocolea lanata*, (3) *Lepidozia reptans*, (4) *Saccogyna antarctica*, (5) *Lophozia Mildeana*, (6) *L. excisa*, (7) *Frullania Grevilleana*, (8) *F. lobulata*, (9) *Mastigolejeunea humilis*, (10) *Moerckia hibernica*, (11) *Fossombronia cristata*, (12) *F. angulosa*, (13) *F. Dumortieri*, (14) *Sphaerocarpus Michelii*. All × 500

Elizabeth M. Knox

In all these families the spore structure exhibits a remarkable degree of uniformity. With few exceptions the spores are small, ranging from 8 μ to 20 μ in diameter, thin-walled and smooth or finely granular, papillose or muricate (figs. 1 to 6). It is of interest that these features are characteristic also of the spores of mosses, and the view has been expressed by von Wettstein (1924) that "the leafy Liverworts, especially the *Haplomitriaceae* and the *Acrogynae* among the *Jungermaniales*, come nearest to the moss type in many respects." Within the group, however, some exceptions to this generalisation have been observed. In the genus *Frullania* the spores of all the species examined range from 40 μ to 60 μ in diameter, are obtusely angular in outline and exhibit either dark circular markings on the wall as in *F. Grevilleana* (fig. 7) or rounded papillae arranged in small circular groups as in *F. lobulata* (fig. 8). The latter type of ornamentation is seen also in *Madotheca brasiliensis*, while in *Mastigolejeunea humilis* (fig. 9) the finely spinose wall bears short, pointed, incurved teeth likewise arranged in small circular depressions.

Jungermaniales anacrogynae.

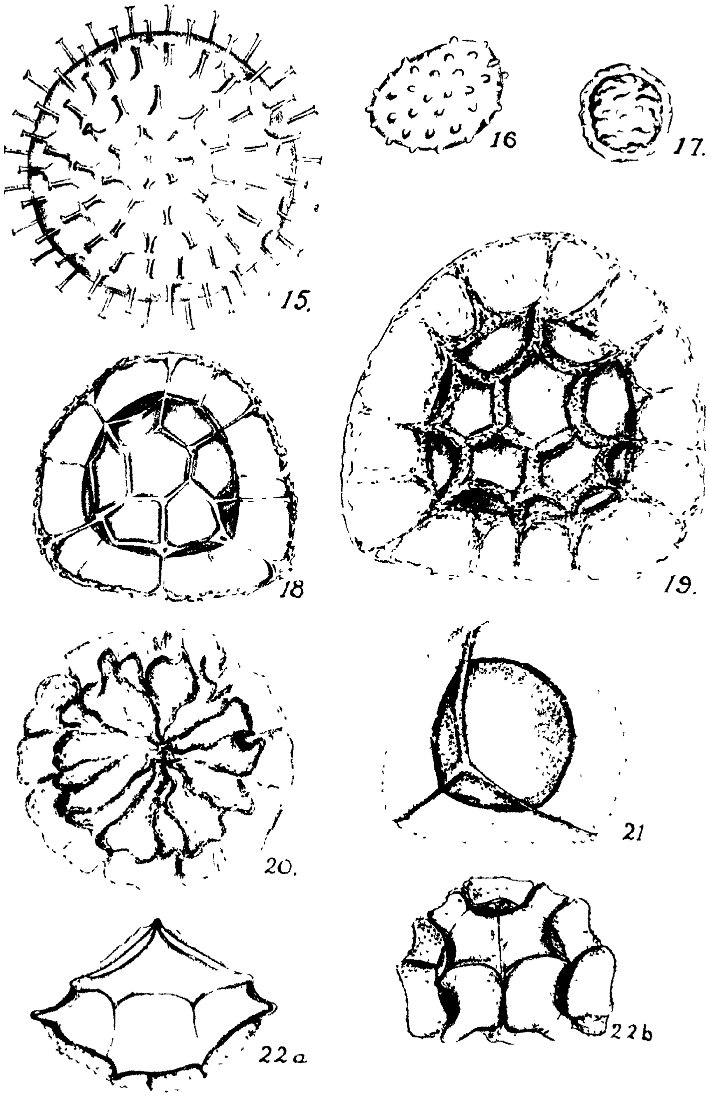
Of the seven families belonging to this group examples have been examined from the *Codoniaceae*, *Haplolaenaceae*, *Monocleaceae*, *Dilaenaceae*, *Metzgeriaceae* and *Aneuraceae*.

Among these families the spores show little divergence either in size or ornamentation from those of the Jungermaniales acrogynae except in the *Codoniaceae* and in the genus *Moerckia*. The latter includes species in which the spores are furnished with short irregular ridges, the margin appearing coarsely papillose as in *Moerckia hibernica* (fig. 10). In the *Codoniaceae* which includes *Petalophyllum* and *Fossombronia*, the spores are sufficiently distinctive to be used for diagnostic purposes and, in fact, the subdivision of the genus *Fossombronia* by Stephani (1900), Pearson (1902) and others has been based upon spore characters. Three sections are recognised: (1) spores with furcate ridges, (2) spores with lamellae forming conspicuous alveolae, (3) spores with coarse papillae. To the first section belongs such species as *F. cristata* (fig. 11) in which the furcate ridges appear on the margin as prominent papillae, while *F. angulosa* and *F.*

Dumortieri (figs. 12 and 13) illustrate two types of the reticulate spore characteristic of species placed in the second section of the genus. In *F. angulosa* the lamellae are very prominent, forming deep hexagonal alveolae, and the margin of the spore appears as if surrounded with a transparent angulate wing. In *F. Dumortieri* the lamellae are not so high, and while the spore wall is regularly reticulate it has no conspicuous wing, the margin appearing crenulate. In the third section of the genus the spores are furnished with coarse, more or less truncate, papillae as seen in *F. caespitiformis*, while in the allied genus *Petalophyllum* they are reticulate, the lamellae again giving the appearance of a distinct wing.

Sphaerocarpales.

The Sphaerocarpales as defined by Verdoorn include two families represented by *Sphaerocarpus* and *Riella*. In both genera the spores are large, ranging from 60 μ to 120 μ in diameter. In the genus *Sphaerocarpus* (fig. 14) they remain in tetrads, except in *S. Donellii* and *S. cristata* where the spores separate before they are liberated from the sporogonium, and in this feature these two species seem to connect with *Riella*. Both genera are characterised by the heavy ornamentation of their spores; in *Sphaerocarpus* (fig. 14) the lamellae form distinct reticulations which appear papillate or crenulate in optical section, while in *Riella* (fig. 15) the wall is invariably beset with numerous outgrowths which may be little more than short tubercles, but more frequently they are rod-like in appearance and may be truncate, slightly dilated, emarginate or more rarely acute. In *Riella americana* these outgrowths are as long as 24 μ. Although scarcely perceptible in *R. helicophylla* (fig. 15) the spore wall in some species of the genus exhibits irregular reticulations formed by the more or less confluent basal membranes of the emergences. As in many other spores the architectural features of the wall are more pronounced on the ab-apical than on the apical surface, while in *R. alatospora*, described by Wigglesworth (1937), the spore, in addition to being coarsely spinose, possesses an equatorial winglike extension of the wall.



FIGS. 15–22. Spores of (15) *Riella helicophylla*. (16) *Dumortiera hirsuta*. (17) *Marchantia Schadenbergii*. (18) *Fimbriaria micropoda*. (19) *F. australis*. (20) *F. angusta*. (21) *Plagiochasma rupestre*. (22 *a*) *P. subplanum*, side view. (22 *b*) ab-apical view. Figs. 15–17 are ×500, figs. 18–22 are ×333.

ELIZABETH M. KNOX

Marchantiales.

In the Marchantiales which includes the families *Marchantiaceae*, *Operculatae*, *Targioniaceae*, *Corsiniaceae* and *Ricciaceae*, the spores show greater variation in size and architecture than in any other group of Hepaticae and few of the families are characterised by constancy of spore structure. In the *Ricciaceae*, however, though there is considerable variation in detail, the spores in the majority of species conform to the reticulate type.

The *Marchantiaceae* have spores which are thin-walled and very variable in size ranging from about 12 μ in *Marchantia polymorpha* and *Lunularia cruciata* to about 90 μ in *Conocephalum conicum*. In the latter, however, the spore is multicellular when shed. The wall may be smooth, granular or coarsely papillose as in *Dumortiera hirsuta* (fig. 16), while in some cases it is thrown into irregular folds giving a wrinkled appearance as in *Marchantia Scheidenbergii* (fig. 17) and *Preissia quadrata*.

Some of the largest spores among Liverworts are to be found in the *Operculatae*. In *Fimbriaria* (*Asterella*) they may be 150 μ in diameter and large spores are seen also in *Plagiochasma* and *Reboulia*. They are commonly reticulate, though the details of design vary greatly according to the height and disposition of the lamellae. In *Fimbriaria macropoda* (fig. 18) the reticulum is wide and open and the spore has a prominent, transparent border 10 μ to 15 μ broad, strengthened by thickened ridges. Though still referable to the reticulate type, the ornamentation is even more elaborate in the case of *Fimbriaria australis* (fig. 19) where both the alveolar surfaces and the conspicuous plicate border are finely granular. Within the genus a deviation from the usual type is seen in *F. augusta* (fig. 20) where the outer coat of the spore forms a loose mantle thrown into irregular folds. In *Plagiochasma* (figs. 21 and 22) the spores range from 60 μ to 100 μ in diameter, are reticulate, at least on the ab-apical surface, and possess a wide spinulose border with finely toothed or sinuous margin. The spores of *Reboulia hemisphaerica* (fig. 23), which measure about 80 μ have a few large alveolae and a broad sinuate margin. The development of these structures has been traced by Blair (1926) who shows that the formation of the several

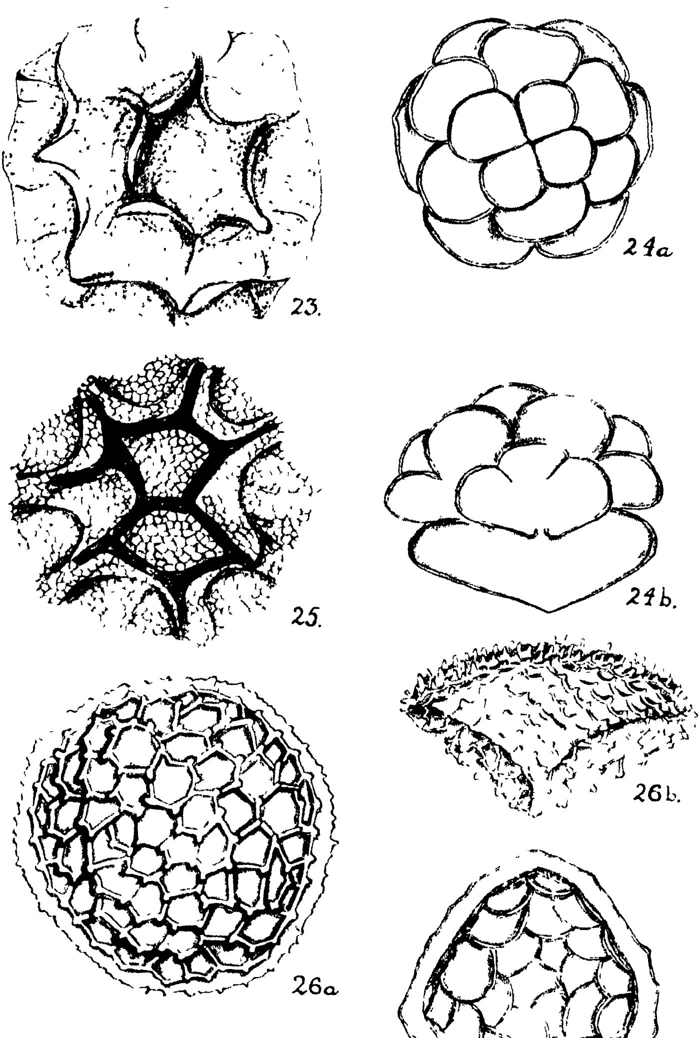
layers is related to the activity of the plasma membranes, the outer layer being thrown into large folds which form the flanges of the mature spore. A unique type of spore is found in *Grimaldia dichotoma* (figs. 24 *a* and *b*) where the wall on the ab-apical side is studded with swollen vesicles, 20 μ across, giving the appearance of a neat rosette, while on the apical side there is a single large air-sac. These bladders have been regarded as analogous to the air-sacs on the pollen grain of *Pinus*.

In the family *Targioniaceae*, of which only *Targionia hypophylla* (fig. 25) has been examined, the large spores show a double network; the outer wall, itself finely reticulate, is so folded as to form a loose reticulum with large alveolae surrounded by high lamellae.

The tetrahedral spores of the *Ricciaceae* vary in size from 80 μ to 200 μ and, with few exceptions, are of the reticulate type as seen in *Riccia Beyrichiana* (figs. 26 *a* and *b*) and *R. fluitans* (fig. 27). The alveolae are usually relatively small, so that a considerable number are seen across the spore diameter, in contrast to the large alveolae of some of the types already described. The angles of the reticular meshes bear projecting papillae (fig. 26) and these may occur also in the few species where the regular network is replaced by a series of anastomosing ridges, some of which form irregular and incomplete alveolae as in *R crystallina* (fig. 28). A distinctive character of all spores of the *Ricciaceae* is the well-marked transparent and frequently crenulate border usually about 10 μ wide.

Anthocerotales.

The single family *Anthocerotaceae* includes five genera from all of which representatives have been examined. The spores measure from 35 μ to 60 μ in diameter and three distinct types of ornamentation have been observed, the structural characters being accompanied by differences in colour. The features concerned will be briefly described from examples selected from the genus *Anthoceros*. In *A. punctatus* (fig. 29) and allied species the spores are dark brown or almost black in colour and are furnished with stiff, rigid spines which are frequently curved and in some species tend to be united by their dilated bases so as to produce a pseudo-reticulate



FIGS 23-27 Spores of (23) *Reboulia hemisphaerica*, (24 *a*) *Grimaldia dichotoma*, ab-apical view, (24 *b*) side view, (25) *Targionia hypophylla*, (26 *a*) *Riccia Beyrichiana*, ab-apical view, (26 *b*) side view, (27) *R fluitans* All × 500

ELIZABETH M KNOX

appearance similar to some of the *Riellaceae.* A second group of species is characterised by the pale green colour of the spores which are relatively thin walled and granular, but possess also stout, blunt protuberances 4 μ to 7 μ long and 3 μ to 5 μ wide. These excrescences are well seen in *A. chilensis* (fig. 30) where they are restricted to the ab-apical side of the spore. The third group of species includes those having yellowish green spores with granular, papillate or at most rough or warty walls as in *A. dichotomus*, *A. tuberosus* and *A. philippinensis.* The features observed in the spore structure of the genus *Anthoceros* are to be found also in *Asperomites*, *Dendroceros*, *Megaceros*, and *Notothylas.*

Musci.

Although there is much variety in the gametophyte and sporophyte of mosses, the spores themselves are monotonously uniform. Among some 500 species which have been examined belonging to a large number of genera, the diversity in spore morphology proves to be even less than is seen within a single large genus of the Pteridophyta such as *Selaginella.* It becomes at once evident that spore structure would be of very limited taxonomic value and there is little probability that fossil spores could be related with any certainty to those of existing mosses. It is unnecessary, therefore, to give a systematic description of these spores and reference will be made only to the more outstanding variants which have been observed.

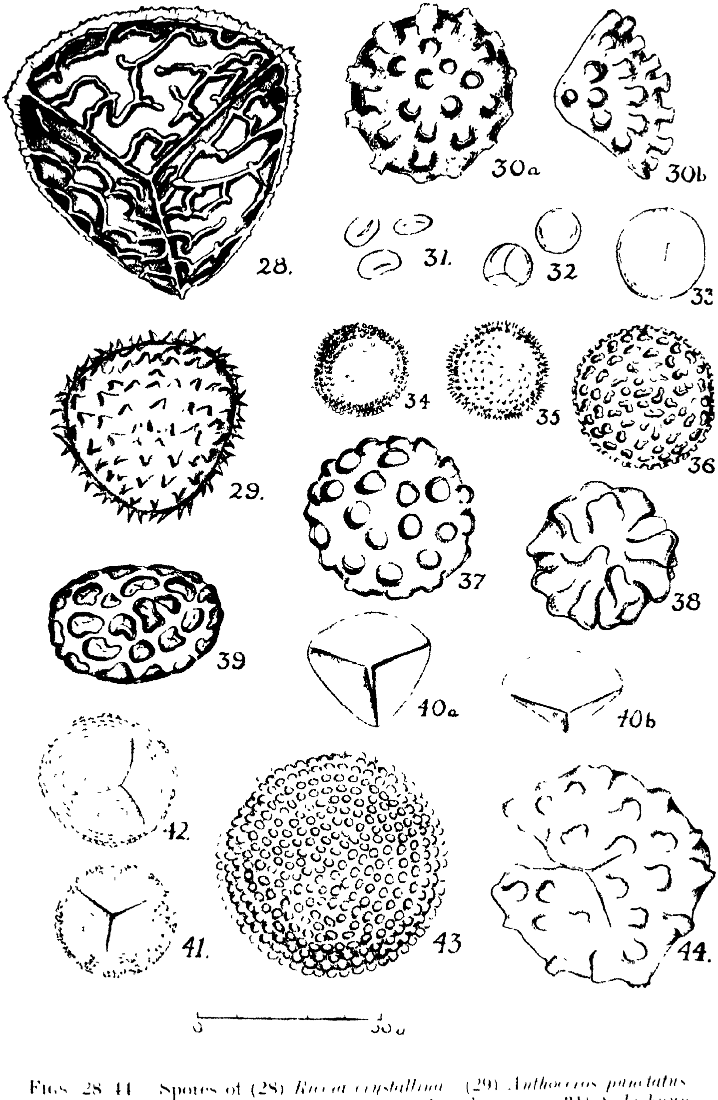
The majority of species have spores which measure from 10 μ to 20 μ in diameter, but in some they are less than 10 μ while in *Ephemerum* they measure 70 μ to 80 μ and in *Archidium* may be as large as 200 μ. They are mostly spherical although some are oval or bean-shaped as in *Splachnum* (fig. 31), while in *Sphagnum* (fig. 40) they are invariably tetrahedral. While perfectly smooth spores are not uncommon the majority, irrespective of size, are granular, punctate, papillose or spinulose as in *Brachyodus trichodes*, *Hedwigia ciliata*, *Pottia lanceolata* and *Psyscomitrella patens* (figs. 32 to 35 respectively). An unevenly papillate type is seen in *Oedipodium Griffithianum* (fig. 36), while *Tortula suberecta* (fig. 37) illustrates a coarsely tuberculate or warty

form and in *Encalypta vulgaris* (fig. 38) the spore wall is marked by irregular foldings, similar in disposition to those noted for *Fimbriaria augusta* (fig. 20). None of these forms, however, is common and their rarity is therefore of special interest. A still rarer condition is seen in *Breutelia arcuata* (fig. 39) where the spore wall is studded with dark brown thickened patches recalling the nature of the wall in *Frullania Grevilleana* (fig. 7) where, however, the thickened areas are smaller and more widely spaced. Uniformity in spore structure is particularly noticeable in the *Sphagnaceae* where the spores are of a characteristic spherico-tetrahedral shape and have a well-defined triradiate crest on the apical surface. The spores in *Sphagnum* (fig. 40) vary from 25 μ to 40 μ in diameter and the wall may be smooth, granular or verruculose. In no instance has a moss spore been observed where the wall showed any reticulate ornamentation so commonly met with in the Hepatics and the absence of this particular feature among moss spores is especially noteworthy.

Fossil Spores of Carboniferous Age.

Both liverworts and mosses are widely distributed, the genus *Sphagnum*, for example, being almost cosmopolitan. There is evidence to suggest that this wide distribution was already established in Carboniferous times (Campbell, 1907) and the scarcity of fossil Bryophytes may be attributed to the delicate nature of the tissues. Bryophytes had evidently reached a considerable degree of specialisation, however, in Palaeozoic times as indicated by the discoveries of Walton (1925, 1928) and since the Carboniferous coals contain an abundance of fossil spores it may be supposed that some of them are bryophytic.

Both in size and ornamentation the variety of fossil spores which the author has examined from the Productive Coal Measures of Fife is as great as among the modern spores of liverworts and mosses. Moreover, various types of fossil microspores have been described by Raistrick (1933, 1934) and others, which have not so far been recognised as having any near counterpart among existing forms. Nevertheless, in my previous paper a comparison was made between some of the micro-fossils and spores of certain ferns or their allies,



FIGS. 28–44. Spores of (28) *Riccia crystallina*. (29) *Anthoceros punctatus*. (30 *a*) *A. chilensis*, ab-apical view, (30 *b*) side view. (31) *Splachnum ampullaceum*. (32) *Brachyodus trichodes*. (33) *Hedwigia ciliata*. (34) *Pottia lanceolata*. (35) *Physcomitrella patens*. (36) *Oedipodium Griffithianum*. (37) *Tortula suberecta*. (38) *Encalypta vulgaris*. (39) *Breutelia arcuata*. (40) *Sphagnum fuscum*. (41–44) Microspores from Carboniferous coals of Fife. All ×500.

ELIZABETH M. KNOX.

and attention may now be drawn to some of the resemblances which exist between Carboniferous spores and those of living Bryophytes.

The smooth, granular or papillose structure of the wall so commonly seen in spores of living mosses and liverworts is frequently found also among the fossils. In fig. 41, for example, a fossil form having a finely granular wall with well-marked tri-radiate crest is illustrated, while different degrees of papillose development are seen in figs. 42 and 43. The coarsely tuberculate specimen depicted in fig. 44 may be compared with the spore of *Anthoceros chilensis* (fig. 30) though it lacks the granular markings, while fig. 45 exemplifies a type similar to *Moerckia hibernica* (fig. 10), the fossil, however, is of a coarser texture and larger in size. The spore architecture in *Anthoceros punctatus* (fig. 29) bears a striking resemblance to that of the fossil shown in fig. 46; while another fossil (fig 47) the pattern of which is formed by vermiform and anastomosing ridges, may be compared to *Riccia crystallina* (fig. 28). In fig. 48 a form recalling *Riccia Beyrichiana* (fig. 26) is seen, though the fossil spore lacks the transparent margin. The well-defined border and regular reticulation of *Riccia fluitans* (fig. 27) has its counterpart in the spore illustrated in fig. 49, but in the fossil the reticular meshes are wider. Amongst the fossils also there occur spores which, though poorly preserved, retain sufficient structure to indicate that they are representatives of types which possessed large alveolae with high lamellae (*e.g.* fig. 50) similar to *Fossombronia angulosa* (fig. 12). The curious spore illustrated in fig. 51 possesses structural features which are suggestive of *Plagiochasma subplanum* (fig. 22), though in the fossil the outer wing has suffered erosion. The peculiar forms of spore structure seen in *Frullania* (figs. 7 and 8), *Mastigolejeunea* (fig. 9), *Grimaldia* (fig. 24), *Targionia* (fig 25) and *Breutelia* (fig. 39) have not been recorded so far from coals of Carboniferous age

Though it is possible to draw broad comparisons between existing and fossil spores it is not suggested, at this stage of the investigation, that any specific or even generic significance can be attached to them. As shown in my previous paper, some of the forms bear a distinct likeness to the spores of Pteridophyta, and it is evident that others approach fairly

closely, though they do not correspond exactly, to some of the spores of Bryophytes described in the foregoing pages. Except where fossil spores are found in organic union with recognisable parent material, however, there can be no certainty as to their true relationship.

Summary.

This paper gives a short account of the spores of liverworts and mosses, various examples being figured to aid in the elucidation of the great variety of spores found as microfossils in coals of Carboniferous age. The paper is arranged so as to be comparable with the previous one on the spores of Pteridophyta.

The spores of Hepaticae show great variation in size and structural detail; those of mosses are generally small and more uniform in appearanc, ebut unusual types are occasionally represented in certain genera.

Further examples of fossil spores from the Productive Coal Measures of Fife are given and comparisons are drawn between these and existing forms, but no close relationship can, at present, be suggested. Great diversity in spore structure had already appeared in the Palaeozoic, but among modern spores certain forms have been noted which have not yet been recognised among fossils.

Acknowledgments.

I am again indebted to Professor Sir William Wright Smith for facilities to carry out this investigation and for a generous supply of material. To Professor J. R. Matthews, who suggested the investigation, I am grateful for much assistance in the preparation of the paper; and to the Carnegie Trustees I am indebted for a Grant in aid of the research and for contributing towards the cost of the illustrations.

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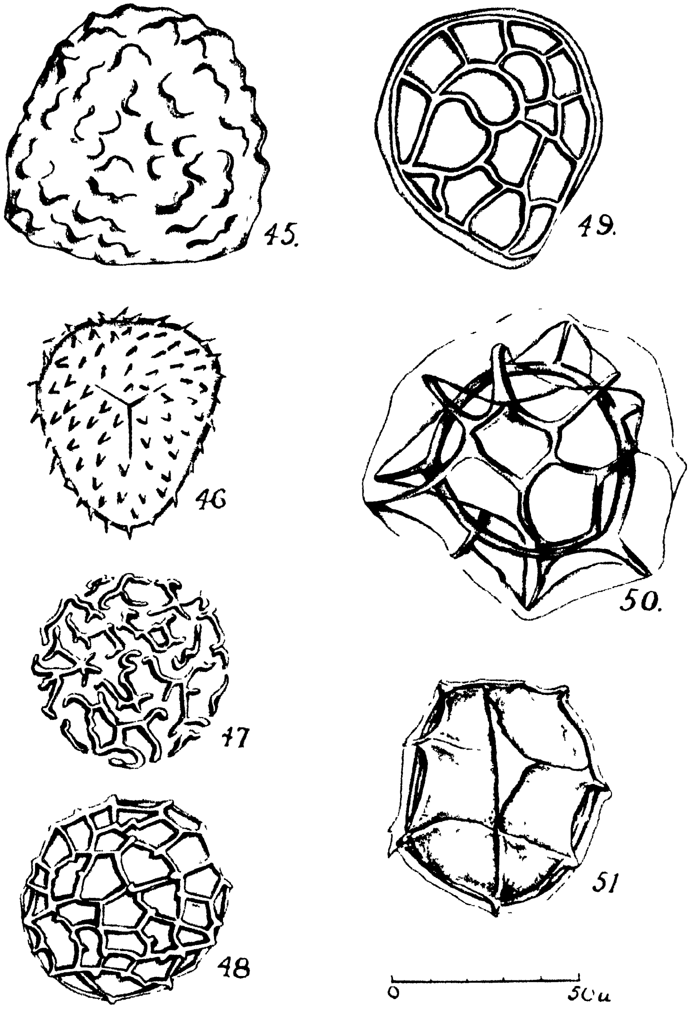

Figs. 45–51.—Microspores from Carboniferous coals of Fife. All × 500.

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THE MARINE ALGAE OF ST. ANDREWS BAY. By MARY D. DUNN, B.Sc. (with map of district).

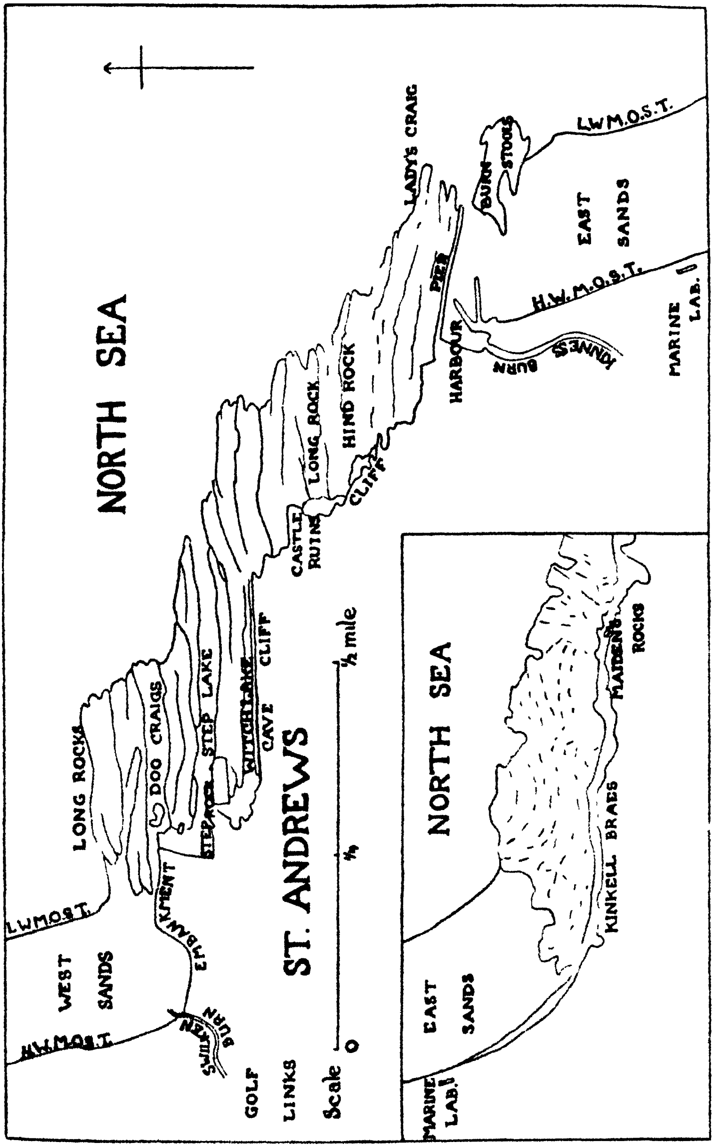
(Read 20th April 1939.)

St. Andrews is situated on the east coast of Fife, in latitude 56° 20′, on the Bay of the same name, with a north and north-easterly aspect. The Bay is bounded on the north by the estuary of the River Eden which is tidal for about five miles from the sea. A wide stretch of mud is exposed here at low water, edged by a series of salt marshes. From the estuary the West Sands stretch in a south-easterly direction for about two miles to the town. These sands are entirely devoid of marine algae. The shore round the town is very rocky, and is backed by cliffs which are washed by the sea at high tide. These Carboniferous rocks are mainly of sandstone and lie in long parallel ridges with channels between, locally called lakes, which fill up very quickly when the tide turns. These lakes are mainly sandy and a good deal of sand is deposited on the rocks and held together by sand-binding algae. Towards the south-east of the town the Kinness Burn runs into the harbour, bringing down a considerable amount of silt which is spread over the rocks on both sides. The East Sands, stretching from the harbour south-east to the Kinkell Braes, has numerous embedded stones which carry a considerable flora. At the Kinkell Braes the littoral region is again rocky but the cliff here, being farther back, is not reached by the tide, though it shades the upper part of the shore. This rocky shore runs eastwards, becoming more exposed as it leaves the shelter of the Bay.

Only the part of the shore round the town and along the Kinkell Braes as far as the Maiden Rocks is shown on the map, but references are made to collecting stations at the mouth of the Kenly Burn and Pitmilly, which lie about four miles eastwards.

Very little has been published on the marine algae of St. Andrews, although several workers made collections there during last century. Work was begun again in 1935, when D. N. Lowe (1935) started to survey the seaweeds of the

district, and this has been continued by the present writer during the years 1936–9. The accompanying list of marine



algae has been compiled during these years, collecting having been done at all times of the year and the material examined

in a fresh state. An account of the algal communities and their seasonal changes which have been examined will be published later—this preliminary list indicating merely the relative frequency and the district for those algae which are not found at all parts of the shore.

List of Marine Algae collected at St. Andrews during 1936–1939.

Those marked with an asterisk have not already been recorded for Fife. h.w.—high water. l.w.—low water.

Myxophyceae.

**Chroococcus turgidus* Naeg. Local. Associated with other algae on salt marshes.

Dermocarpa prasina Born. Frequent. Epiphytic on various algae.

**Spirulina subsalsa* Oersted var. *oceanica* Gom. Local. On mud of Eden estuary.

**Oscillatoria margaritifera* Kütz. Local. On mud of Eden estuary.

**Oscillatoria nigroviridis* Thwaites. Frequent. In muddy crevices at h.w. and on salt marshes.

**Oscillatoria laetevirens* Crouan. Local. On clay bank of salt marsh far up the Eden.

Lyngbya aestuarii Liebm. Occasional. At h.w. and on salt marshes.

Microcoleus chthonoplastes Thur. Local. On salt marsh.

**Calothrix consociata* Born. et Flah. Rare. East of Maiden. Epiphytic on *Polysiphonia violacea*.

Calothrix scopulorum C. A. Agardh. Frequent. On rocks at h.w.

Calothrix pulvinata C. A. Agardh. Frequent. In muddy crevices at h.w. and on salt marshes.

Rivularia atra Roth. var. *confluens* Farlow. Frequent. On cliffs and on vertical banks of salt marshes.

**Rivularia nitida* J. G. Agardh. Local. Witch Lake. On cliff, often epiphytic on *Cladophora rupestris*.

Nostoc commune Vauch. Occasional. On salt marsh far up river.

Chlorophyceae.

Chlorochytrium inclusum Kjellm. Occasional. In thallus of *Dilsea edulis*.

**Chlorochytrium Cohnii* Wright. Frequent. In mucilage tubes of *Schizonema* sp.

Protococcus marinus Kütz. Occasional. Among other algae at h.w.

**Codiolum Petrocelidis* Kuck. Rare. Among the filaments of *Petrocelis cruenta*.

Ulothrix flacca Thur. Occasional. On cliffs in drip of fresh-water. On stones in bed of Swilken Burn.

**Ulothrix speciosa* Kütz. Occasional. Entangled in pools and epiphytic.

**Gloeocystis adnata* Naeg. (*Phaeococcus adnatus* West). Frequent. On vertical cliffs in splash zone.

Enteromorpha clathrata J. G. Agardh. Rare. Found once cast ashore in Witch Lake.

**Enteromorpha torta* Reinb. Frequent. On rocks at h.w. and on salt marsh.

**Enteromorpha prolifera* J. G. Agardh var. *tubulosa* Reinb. Local. On salt marshes.

**Enteromorpha prolifera* J. G. Agardh var. *capillaris* Kütz. Local. On sand-covered rocks north of embankment.

**Enteromorpha prolifera* J. G. Agardh var. *trichodes* Batt Local. Eden estuary. Spread in masses on the mud.

**Enteromorpha crinita* J. G. Agardh. Local. Eden estuary. On mud.

Enteromorpha compressa Grev. Frequent. On rocks and in pools.

**Enteromorpha compressa* Grev. var. *intermedia* Chapman. Frequent. On sandy rocks and in pools.

Enteromorpha intestinalis Link. General. At h.w. and in fresh water entering sea.

**Enteromorpha micrococca* Kütz. var. *tortuosa* J. G. Agardh. Frequent. On steep rocks at h.w.

Enteromorpha minima Naeg. Frequent. At h.w., especially between West Sands and Pier and on salt marshes.

Monostroma Wittrockii Born. Local. In pan on salt marsh.

Monostroma fuscum Wittr. emend. Rosenv. Frequent. Near l.w. and in inlets.

Monostroma Grevillei Wittr. emend. Rosenv. General. In pools, often epiphytic.

Percursaria percursa Rosenv. Frequent. On h.w. rocks and salt marshes.

Ulva lactuca Linn. var. *latissima* DC. General. On rocks and in pools.

Ulva Linza J. G. Agardh var. *lanceolata* Kütz. Frequent. On rocks in littoral zone, submerged at l.w., on mud of Eden estuary.

Prasiola stipitata Suhr. Frequent. On detached rocks not submerged at h.w.

**Prasiola crispa* Meneghini. Rare. Kinkell, east of Maiden. On h.w. rocks.

Cladophora rupestris Kütz. General. On rocks and in pools.

**Cladophora hirta* Kütz. Frequent. In h.w. pools, often epiphytic.

Cladophora sericea Kütz. Occasional. Kinkell. In pools.

Cladophora flexuosa Harv. Occasional. East Sands and Kinkell. In pools, often epiphytic.

Cladophora refracta Aresch. Occasional. Kinkell. In pools.

Cladophora albida Kütz. Frequent. Kinkell. In pools near l.w.

**Cladophora fracta* Kütz. var. *marina* Hauck. Local. On mud of Eden estuary.

Cladophora arcta Kütz. General. On sandy rocks.

This is very common on the sand-covered rocks, where the numerous rhizoids act as sand binders. It agrees with the description of *Acrosiphonia albescens* Kjellm. given by Borgesen (1902), having blunt branches, very pointed branches and hooked branches, the latter becoming more numerous in the older plants.

Cladophora artiuscula Kütz. Occasional. Probably young stage of *C. arcta*.

Cladophora lanosa Kütz. Frequent. Epiphytic on various algae.

Cladophora lanosa Kütz. var. *uncialis* Thur. Frequent. On rocks near l.w. and on cliff in Witch Lake at h.w.

Chaetomorpha tortuosa Kütz. Frequent. Entangled in pools.

Chaetomorpha linum Kütz. Local. On mud of Eden estuary.

Chaetomorpha melangonium Kütz. Frequent. In pools.

**Rhizoclonium implexum* Batt. Local. On salt marshes.

Rhizoclonium riparium Harv. General. On h.w. rocks.

**Rhizoclonium Kerneri* Stockm. var. *endozoica* Wille. Occasional. In tissues of *Halichondria panicea.*

Urospora isogona Batt. Frequent. On rocks near h.w.

Bryopsis plumosa C. A. Agardh. Occasional. In small pools between Doo Craig and Castle.

**Vaucheria dichotoma* Lyngb. var. *submarina* C. A. Agardh. Occasional. Under shelves of rock near Doo Craig and in cave, Witch Lake.

**Vaucheria Thuretii* Woron. Frequent. On mud, especially in Eden estuary.

**Vaucheria sphaerospora* Nordst. var. *synoica* Nordst. Frequent. On mud north of embankment and in Eden estuary.

Vaucheria coronata Nordst. Frequent. On sandy mud at and above h.w. *V. dichotoma* and *V. coronata* have not been found fertile, but have been named by vegetative growth and habitat.

PHAEOPHYCEAE.

**Ectocarpus parasiticus* Sauv. Frequent. Parasitic on *Polysiphonia nigrescens*, *Ceramium rubrum* and *Cystoclonium purpureum.*

Ectocarpus velutinus Kütz. General. Parasitic on receptacles of *Himanthalia lorea.*

Ectocarpus confervoides Le Jol. Frequent. In pools and as an epiphyte.

Ectocarpus siliculosus Kütz. Frequent. In pools and as an epiphyte.

Ectocarpus fasciculatus Harv. Frequent. Epiphytic on *Laminaria* spp., *Himanthalia lorea* and *Rhodymenia palmata.*

Ectocarpus tomentosus Lyngb. General. Epiphytic on *Fucus* spp.

**Ectocarpus Hincksiae* Harv. Occasional. Epiphytic on *Laminaria* spp. and *Rhodymenia palmata.*

Ectocarpus granulosus C. A. Agardh. Occasional. Between West Sands and Castle. In pools.

Pylaiella littoralis Kjellm. General. On rocks and as epiphyte on *Fucus* spp., *Cladophora rupestris*, and *Poly-*

siphonia nigrescens. On mud of Eden estuary and salt marsh.

This is a different distribution from that given by Knight (1923), who finds it epiphytic on *Fucus* spp. and *Ascophyllum nodosum*, sometimes spreading to stones and rocks in the vicinity. At St. Andrews, it is present all the year as a short growth, 1–2 ins. high, covering the rocks amongst the *Fucus* plants. In February it appears as an epiphyte on *Cladophora rupestris* in some h.w. rock pools, later spreading to *Fucus ceranoides* and *Polysiphonia nigrescens* and only occasionally to *Ascophyllum nodosum*. From May onwards it is found on *Fucus vesciculosus* and *F. serratus* as large plants up to 20 ins. These disintegrate in autumn.

In the Eden estuary *Pylaiella* is also found all the year growing on the mud and on the escarpments of the salt marshes, a similar habitat to that found by Chapman (1937) in Norfolk.

**Mikrosyphar Porphyrae* Kuck. Rare. Kinkell. Epiphytic on *Porphyra umbilicalis*.

Leptonema fasciculatum Reinke. Rare. Lady's Craig. Epiphytic on *Laminaria*.

Elachistea fucicola Fries. General. Epiphytic on *Fucus* spp.

**Elachistea Grevillei* Arnott. Local. Cliff in Witch Lake. Epiphytic on *Cladophora rupestris*.

Elachistea flaccida Aresch. Rare. Step Lake. Epiphytic on *Halidrys siliquosa*.

Leathesia difformis Aresch. General. Epiphytic on various algae.

Chordaria flagelliformis C. A. Agardh. General. Mid-littoral.

Castagnea virescens Thur. Frequent. In stony pools.

Myrionema strangulans Grev. Occasional. Epiphytic on *Enteromorpha* spp.

Myrionema strangulans Grev. var. *punctiforme* Holm et Batt. Occasional. Epiphytic on *Cladophora rupestris*.

**Myrionema aecidioides* Sauv. Rare. Epiphytic on blade of *Laminaria digitata*.

Ralfsia verrucosa Aresch. General. Encrusting rocks.

**Ulonema rhizophorum* Foslie. Occasional. Epiphytic on *Dumontia incrassata*.

Desmarestia viridis Lamour. Frequently cast ashore. Growing at l.w. Castle and Lady's Craig.

Desmarestia aculeata Lamour. Commonly cast ashore. Found growing once at l.w. Kinkell.

Dictyosiphon hippuroides Kütz. General. Epiphytic on *Chordaria flagelliformis* and other algae.

**Colpomenia sinuosa* Derb. et Sol. Rare. Witch Lake. Epiphytic on *Halidrys siliquosa.*

Asperococcus fistulosus Hook. Frequent. In pools and as an epiphyte.

**Asperococcus fistulosus* Hook var. *vermicularis* Griff. Frequent. In pools near h.w.

Myriotrichia clavaeformis Harv. Occasional. Epiphytic along with *M. filiformis.*

Myriotrichia filiformis Harv. Frequent. Epiphytic on various algae.

Phyllitis Fascia Kütz. General. In pools and in shallow water. On mud of Eden estuary.

Scytosiphon lomentarius J. G. Agardh. Frequent. On rocks and in stony pools.

Stictyosiphon subarticulatus Hauck. Frequent. Doo Craig to Hind Rock. In mid-tide pools.

Litosiphon Laminariae Harv. Local. Epiphytic on *Alaria esculenta.*

Isthmoplea sphaerophora Kjellm. Frequent. Epiphytic on *Plumaria elegans* and *Callithamnion polyspermum.*

Punctaria plantaginea Grev. General. In pools.

Punctaria tenuissima Grev. Occasional. Epiphytic on various algae.

Sphacelaria radicans Harv. Occasional. On rocks at l.w.

Sphacelaria olivacea Pringsh. Frequent. At h.w. on cliffs, in cave, Witch Lake, and on salt marshes.

**Sphacelaria racemosa* Grev. Local. Round Doo Craig. In a few sandy pools.

This species has not been recorded since 1885 when Batters found it at Berwick. It was collected at St. Andrews in February 1937 and again in 1938, at which time it was covered with racemes of ripe sporangia. It disappeared soon afterwards when the sand shifted during rough weather. It is a sporadic species and has not been found in 1939.

Sphacelaria cirrhosa C. A. Agardh var. *pennata* Hauck. General. Epiphytic on various algae.

**Sphacelaria cirrhosa* C. A. Agardh var. *fusca* Holm et Batt. Rare. East of Doo Craig. In pool.

**Sphacelaria cirrhosa* C. A. Agardh var. *aegagropila* Griff. Occasional. Epiphytic on *Halidrys siliquosa.*

**Sphacelaria caespitula* Lyngb. Rare. Epiphytic on stipe of *Laminaria Cloustoni.*

Sphacelaria plumigera Holm. Rare. Witch Lake. In pools at base of cliff.

Chaetopteris plumosa Kütz. Rare. One specimen cast ashore.

Cladostephus spongiosus J. G. Agardh. General. On muddy rocks.

Chorda Filum Lamour. Occasional. Kinkell and Kenly. Cast ashore.

Laminaria saccharina Lamour. Frequent. Cast ashore.

Laminaria hieroglyphica J. G. Agardh. General. Exposed at l.w. and in pools.

Laminaria digitata Lamour. General. Exposed at l.w. and in pools.

Laminaria digitata Lamour. var. *stenophylla* Harv. Occasional. With type.

Laminaria Cloustoni Edmondst. General. Sub-littoral.

Alaria esculenta Grev. Local. Pitmilly. At l.w. and sub-littoral.

**Fucus ceranoides* Linn. Local. Kinkell, west of Maiden Rock. Where fresh water enters sea.

Fucus spiralis Linn. var. *platycarpus* Thur. General. Near h.w.

Fucus vesiculosus Linn. General. Mid-littoral.

Fucus serratus Linn. General. Near l.w.

Ascophyllum nodosum Le Jol. Frequent. Best on rocks in Witch Lake and Kinkell.

Pelvetia canaliculata Dcne. et Thur. General. At h.w.

Himanthalia lorea Lyngb. General. Near l.w. Best on Long Rock and Kinkell.

Halidrys siliquosa Lyngb. General. In deeper pools, mid-littoral. Sub-littoral below Witch Lake.

RHODOPHYCEAE.

Bangia fusco-purpurea Lyngb. Frequent. On rocks near h.w.

Porphyra umbilicalis J. G. Agardh. General. On rocks all over littoral zone.

Porphyra umbilicalis J. G. Agardh var. *vulgaris* C. A. Agardh. Frequent. Near l.w., often epiphytic on *Fucus* spp.

Porphyra umbilicalis form *linearis*. Frequent. On smooth rocks near h.w.

**Erythrotrichia carnea* J. G. Agardh. Frequent. Epiphytic on various algae.

**Goniotrichum elegans* Le Jol. Rare. Epiphytic on *Cladophora* sp.

Acrochaetium virgatulum J. G. Agardh. Frequent. Epiphytic on various algae.

Acrochaetium Daviesii Naeg. Occasional. Epiphytic on various algae.

Gelidium crinale J. G. Agardh. Occasional. Kinkell. In turfs along with *G. corneum*.

Gelidium pusillum Le Jol. Occasional. Kinkell. On mud in crevices at h.w.

Gelidium corneum Lamour. Locally abundant. Kinkell. Forming turfs and in pools, sometimes epiphytic.

Bonnemaisonia asparagoides C. A. Agardh. Rare. Found once cast ashore.

Gloiosiphonia capillaris Carm. Rare. Found once growing in Step Lake.

Dumontia incrassata Lamour. General. In pools and on l.w. rocks.

Dumontia incrassata Lamour var. *crispata* Batt. Frequent. Where exposed to fresh water.

Dilsea edulis Stackh. Frequent. Near l.w.

Furcellaria fastigiata Lamour. Commonly cast ashore. Growing at extreme l.w. Kinkell.

Polyides rotundus Grev. Frequent. In sandy inlets.

Petrocelis cruenta J. G. Agardh. General. Encrusting rocks near l.w.

Petrocelis Hennedyi Batt. Frequent. Epiphytic on *Phyllophora Brodiaei* and *P. membranifolia*.

**Peyssonnelia rubra* J. G. Agardh. Rare. Near l.w. out from Witch Lake, encrusting *Lithothamnion polymorphum*.

Hildenbrandtia prototypus Nardo. General. Encrusting rocks.

Lithophyllum pustulatum Foslie. Frequent. Epiphytic on *Gigartina stellata* and *Furcellaria fastigiata*.

Lithophyllum pustulatum Foslie var. *Laminariae*. Frequent. Epiphytic on *Laminaria* spp.

Lithothamnion Lenormandi Foslie f. typica *Foslie*. General. Encrusting rocks.

Lithothamnion colliculosum Foslie. Frequent. Encrusting rocks.

Corallina officinalis Linn. General. In pools.

Delesseria sanguinea Lamour. Commonly cast ashore. Occasionally small plants growing at l.w.

Membranoptera alata Kylin. Commonly cast ashore. Frequently growing near l.w. and in shade. Epiphytic on *Laminaria Cloustoni*.

Hypoglossum Woodwardii Kylin. Rare. Found once cast ashore.

Phycodrys rubens Batt. Commonly cast ashore. Frequently growing in very shaded places. Epiphytic on *Laminaria Cloustoni*.

**Bostrychia scorpioides* Kutz. Local. On salt marshes.

This plant is considered to be a southern species and has not before been recorded for Scotland. It is abundant on the salt marshes, growing free-living as an undergrowth to the marsh grass, *Glyceria maritima*.

Rhodomela subfusca C. A. Agardh. General. In midlittoral pools.

The observations on this plant differ in some respects from the account given by Harvey and Newton who record lateral stichidia in winter bearing tetraspores only. At St. Andrews the old plants which have survived from the previous season begin active growth in November and produce numerous lateral stichidia which are ripe in January, and bear either tetraspores or cystocarps. Turner (1808) shows this plant under the name of *Fucus subfusca* and pictures lateral stichidia with cystocarps as well as with tetraspores.

Rhodomela lycopodioides C. A. Agardh. Frequent. Kinkell and Kenly. Cast ashore.

Odonthalia dentata Lyngb. Frequent. Cast ashore.

Laurencia caespitosa Lamour. Frequent. In pools.

Laurencia pinnatifida Lamour. General. Type form at l.w. Dwarf form in turfs all over littoral region.

Polysiphonia urceolata Grev. General. On rocks at l.w. and in shade. In cave, Witch Lake.

Polysiphonia nigra Batt. Frequent. West Sands to Pier. In sandy pools and inlets.

Polysiphonia fastigiata Grev. General. Epiphytic on *Ascophyllum nodosum* and *Fucus vesiculosus*.

This plant is generally associated with *Ascophyllum*, though it is sometimes found on *Fucus* spp. (*cf*. Cotton, 1912). Just west of the Maiden Rock, it is found growing plentifully on *F. vesiculosus* far down in this zone. This may be because the *Ascophyllum* at this station grows very far up the shore under the shelter of the cliffs, so that in order to increase its range down the littoral region the *Polysiphonia* invades *F. vesiculosus*.

Polysiphonia elongata Harv. General. In pools.

Polysiphonia fibrata Harv. Rare. In pools below Castle.

Polysiphonia fibrillosa Grev. Rare. In pool, Lady's Craig.

Polysiphonia violacea Harv. Frequent. Castle to Pier and Kinkell. In pools and epiphytic.

Polysiphonia Brodiaei Grev. Frequent. West Sands to Pier. On rocks at l.w. and in pools.

Polysiphonia nigrescens Grev. General. In pools and on rocks.

Brongniartella byssoides Bory. Rare. Found once cast ashore.

Heterosiphonia plumosa Batt. Frequent. Cast ashore.

Spermothamnion Turneri Aresch. Frequent. Epiphytic on various algae.

Griffithsia flosculosa Batt. Frequent. In very shaded places.

**Rhodochorton membranaceum* Magn. Occasional. Cast ashore. Growing in tissues of *Sertularia* sp.

Rhodochorton Rothii Naeg. General. On rocks. Most abundant at h.w. on cliffs and in cave.

Rhodochorton floridulum Naeg. General, but most abundant between West Sands and Pier. On sandy rocks.

Callithamnion polyspermum C. A. Agardh. Frequent. On shaded rocks.

Callithamnion Hookeri C. A. Agardh. Occasional. On shaded rocks.

Callithamnion arbuscula Lyngb. Frequent. On exposed rocks.

Plumaria elegans Schmitz. Frequent. On shaded rocks and in cave.

Ptilota plumosa C. A. Agardh. Frequently cast ashore. Occasionally growing near l.w. Epiphytic on stipes of *Laminaria Cloustoni*.

Antithamnion plumula Thur. Rare. Cast ashore in Witch Lake.

Ceramium diaphanum Roth. Occasional. Kinkell and Kenly. Epiphytic.

Ceramium rubrum C. A. Agardh. General. On rocks and in pools, sometimes epiphytic.

Ceramium flabelligerum J. G. Agardh. Frequent. On shaded rocks.

Ceramium acanthonotum Carm. General. On shaded rocks.

Chondrus crispus Lyngb. General. On rocks at l.w.

Gigartina stellata Batt. General. At l.w. and as undergrowth to *Fucus* spp.

Phyllophora epiphylla Batt. Frequently cast ashore, and growing in shaded pools.

Phyllophora Brodiaei C. A. Agardh. Frequent. At l.w., especially between Castle and Pier.

Phyllophora membranifolia J. G. Agardh. Occasional. Hind Rock and Kinkell. At l.w. and epiphytic on *Laminaria Cloustoni*.

Ahnfeltia plicata Fries. Frequent. In pools and shallow water.

Callophyllis laciniata Kütz. Frequently cast ashore.

Cystoclonium purpureum Batt. General. At l.w. and in pools.

**Cystoclonium purpureum* Batt. var. *cirrhosa* J. G. Agardh. Frequent. With type.

Catenella repens Batt. General. On muddy rocks at h.w. and on salt marshes.

**Choreocolax Polysiphoniae* Reinsch. Occasional. Parasitic on *Polysiphonia fastigiata*.

Rhodymenia palmata Grev. General. At l.w. and below.

**Rhodymenia palmata* Grev. var. *marginifera* Harv. General. At l.w. and epiphytic on *Laminaria Cloustoni*.

Lomentaria articulata Lyngb. General. In shaded places.

Lomentaria clavellosa Gaill. Occasional. Step Rock, Lady's Craig and Kinkell. At l.w.

**Lomentaria rosea* Thur. Rare. Found once cast ashore in Step Lake.

Plocamium coccineum Lyngb. Commonly cast ashore. Found growing at l.w. Kinkell.

**Plocamium coccineum* Lyngb. var. *uncinatum* C. A. Agardh. Rare. Kenly. Cast ashore.

**Rhododermis elegans* Crouan var. *polystromatica* Batt. Rare. Kinkell. Encrusting rocks at l.w.

The writer wishes to thank Dr. V. J. Chapman for help in the identification of the Enteromorphas, and the Botanical Department of St. Andrews University for assistance and facilities to carry out the work. The survey has been conducted during the tenure of a Scholarship from the Carnegie Trust, to whom the author also expresses thanks.

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Notes on Lichens in the Herbarium of the Royal Botanic Garden, Edinburgh. II. By Walter Watson, D.Sc., A.L.S.

(Read 15th June 1939.)

Since the publication of the first lot of notes in these Transactions (1935) a large number of other lichens have been sent for identification. Most of these were unnamed, but some which had been named were also sent, as it was considered advisable for some revision to be done since some changes had been made in their interpretation. For example, all the material under *Lecanora* (*Aspicilia*) *cinerea* was examined. As expected, the material was heterogeneous. Specimens from Dumfries, Perth, Glenshee, Lochnagar, Kilcully, and Ballygally Head were correctly named, one from Cleveland was *Aspicilia gibbosa*, some of those from the Spittal of Glenshee, Kinnoull Hill, and Kilcully were *A. caesiocinerea*, some of those from Ben Lawers, Lochnagar, and Skye were *Lecidea panaeola* without cephalodia, those from Blackcairn Hill and Sligachan, Skye, were *Pertusaria inquinata*, one from Craigie Hill was *Rhizocarpon petraeum* var. *excentricum*, and one collected by Hardy from Old Cambus I have described as a new species of *Aspicilia*. These results are of interest as showing how the concept of the species is narrower to-day than it was in Lindsay's time. No doubt those which belonged to other genera were attributed to *A. cinerea* by inadvertence.

Most of the specimens were collected in Scotland and, unless the name of another collector is given, by Dr. Lauder Lindsay. Many specimens from herb. W. Smith, Arbroath, were examined. Some other specimens were collected by Moore, Gilchrist, Carrington, Hardy, Larbalestier, W. Johnson, and E. M. Holmes. The date of collection was usually given on the accompanying label, but from consideration of space is generally omitted in these notes. Sufficient dates are, however, given to enable the reader to get some idea of the times when the collections were made. The numbers refer to the botanical vice-counties of the localities where the lichens

were collected. The chief vice-counties mentioned are 83 (Edinburgh), 85 (Fife), 87, 88, 89 (W., Mid, and E. Perth respectively), 90 (Forfar), 92 (S. Aberdeen), 96 (E. Inverness), 98 (Argyll, Main.), 104 (N. Ebudes, including Skye, etc.), 110 (Outer Hebrides), and 111 (Orkneys). Mr. Young has rendered valuable assistance in assigning the localities to their proper vice-counties. In a few cases lack of detailed geographical information has prevented the insertion of the vice-county, and any information to supply the blanks would be welcomed.

The addition of an asterisk to the vice-comital number indicates that the plant was not previously recorded for the vice-county. It will be noticed that the asterisks are so frequent that they indicate the great progress which has been made in the knowledge of the geographical distribution of lichens in Scotland.

Two new species have been created from the material. The *Aspicilia* collected by Hardy at Old Cambus has been named *A. cambusiana*, and another *Aspicilia* collected by Lindsay on Craig Rossie has been designated *A. Lindsayi*. Three species, *Biatora Casimiri*, *Rinodina biatorina*, and *Verrucaria collematodes* are new to the British Isles, whilst *Pertusaria amarescens* had not been recorded till recently. *Lecidea cinerascens* var. *elevata*, *L. lapicida* form *plumbescens*, *L. pantherina* f. *hypophaeiza*, *Parmelia sulcata* f. *rubescens* and *Aspicilia cinerea* f. *alba* are also new records for the British Isles. The following are new for Scotland: *Lecidea lulensis* (*leucophaeoides*), *L. percontigua* v. *pruinosa*, *Biatora coarctata* v. *elachista* form *depauperata*, *Pertusaria amarescens*, *P. pertusa* v. *leiotera*, *P. inquinata* f. *nolens*, *Biatorina baeomma*, *Placodium callopisma* v. *plicatum* f. *thallincolum*, *Rhizocarpon petraeum* v. *excentricum* f. *coarctatum*, *Synechoblastus Laureri*, *Allarthonia phaeobaea* (*paralia*), *Verrucaria prominula* and vars. *minor* and *viridans*, and *Polyblastia subinumbrata*.

In the former notes on lichens (1935) reference was made to certain species of *Usnea* created by Stirton and published in the Scottish Naturalist about 1883–1884. The likeness of *U. protensa* Stirt. to *U. sublurida* was commented upon in my notes, and Motyka has included it under that species. Since my notes were written Motyka has published his Monograph of Usnea, and some comments on his references to

Stirton's species should be of interest in a Scottish journal. *U. rubicunda* Stirt. is used for the more rubescent plants formerly included with *U. sublurida* in the wider ambit of *U. rubiginea* (Mich.) Herre. *U. subpectinata* Stirt. and *U. constrictula* Stirt. are included together under the former name. *U. intexta* Stirt. is used as Stirton used it, whilst *U. hirsutula* Stirt. is given as a synonym of *U. comosa* (Ach.) Roehl., under which many of the plants, formerly placed under *U. hirta*, fall. Thirty-six Stirtonian names are used in a specific sense in Motyka's Monograph. Most of these are foreign Usneas but, in addition to those mentioned above, *U. chaetophora* Stirt., *U. flammea* Stirt., *U. implicita* Stirt., and *U. mollis* Stirt. are British.

List of Lichens.

(The common plants, unless they are v.c. records, are omitted.)

Parmelia reticulata Tayl. (*P. cetrata* or *P. perforata* of B.M. Monographs). Collected at Ballyer Mt. in 1804. The locality is an Irish one but its vice-county is unknown. There is some doubt about the collector.

P. sulcata Tayl. Dalwhinnie (96). A peculiar form determined by Hillmann as a morbose state of *P. sulcata* f. *rubescens* (Harm.) B. de Lesd. It differs from the type in the reddish colour of the thallus, and has not been previously recorded for the British Isles.

P. omphalodes form *glomulifera* Cromb. Dalwhinnie (96*).

Hypogymnia encausta (Sm.) mihi. *Parmelia encausta* Ach. Dalwhinnie (96*).

Platysma glaucum var. *fuscum* Flot. Nigg (91*), W. Smith.

P. sepincolum (Ehrh.) Hoff. Dalwhinnie (96*).

Cetraria odontella Ach. Dalwhinnie (96*), Ben Nevis (97*).

Lecanora galactina v. *subluta* Nyl. Near Edinburgh (83*), 1856.

L. badia var. *cinerascens* Nyl. Ben Ledi and Pass of Leny (87*).

L. chlarona (Ach.) Nyl. Crichton Gardens (83*), Anon., Ben-y-Glo (89*), W. Smith.

L. chlarotera Nyl. Near Perth (89*).

L. campestris (Schaer.) Hue. West Lomond Hill (85*).

L. gangaleoides Nyl. Clapham (64*), Carrington.

L. carpinea (L.) Vain. Crichton Gardens (83*), Anon., Arbroath (90*), W. Smith.

L. polytropa form *alpigena* (Ach.) Leight., summit of Ben Ledi (87*); form *subglobosa* Cromb., Ben Ledi (87*).

L. intricata Ach. Dalwhinnie (96*).

Ochrolechia tartarea (L.) Mass. Morrone (92), Garrynahine (110). The specimens belong to the form to which the name of *Pertusaria gyrocheila* was given; var. *subtartarea* (Nyl.) (=*O. subtartarea* Mass., =*O. androgyna* (Hoff.) Arn.), Ballyer Mt. From Ireland, but vice-county and collector doubtful.

O. pallescens (L.) Mass. Crichton Gardens (83*), Anon.

Aspicilia caesiocinerea (Nyl) Arn. Spittal of Glenshee and Kinnoull Hill (89*).

A. cinereorufescens (Ach.) Krb. Except that the apothecia are not reddish, some specimens from Ben Ledi (87*) and Garrynahine (110*) agree fairly well with the descriptions of this species, though the Garrynahine specimen has smaller spores.

A. cinerea (Ach.) Krb., Dumfries (72*), Lochnagar (92*); form *alba* (Schaer.) Arn., on calciferous rocks near Perth (89*). Though collected in 1856 this form, in which the thallus is white and the apothecia somewhat pruinose, has not been previously recorded for the British Isles.

A. complanatoides (A. L. Sm.) Wats. Some material from Sciur-na-gillean, Skye (104*), is probably this, but the material is poor.

A. cambusiana Wats., J. of Bot. (1939), 24. On siliceous rock, Old Cambus (82*) *leg.* Hardy in 1856 and placed by Lindsay under *A. cinerea*. Thallus dark yellowish-grey, but with a dark appearance owing to the presence of many dark apothecia, verrucose-areolate, thickish, K–, C–, KC–, I–; algal cells protococcoid, 12–14 μ, sometimes to 20 μ diam., yellowish-green with colourless enclosing sheath 0·75 μ thick; hypothallus darkish but not distinct. Apothecia more or less innate in areolae with indefinite thalline border, more or less concave or plane, about 0·2–0·3 mm. diam. Paraphyses discrete, very slender, indistinctly septate with cells 3–4 times longer than broad, above $\pm$ clavate and bluish, sometimes branched. Hypothecium colourless or slightly brownish, plectenchymatous, with algae below. Ascus elongate-obovate

or ± oblong, wall not or little thickened at apex. Epithecium blue, after potash bluish-green. Spores 8, simple, colourless, oblong, 11–15 × 4–6 μ. Hymenium with iodine blue and then sordid wine-reddish, ascus wall blue and paraphyses yellowish.

A. Lindsayi Wats., J. of Bot. (1939), 25. On siliceous rock, Craig Rossie, Dunning (88*), *leg.* Lindsay in 1858. Thallus yellowish-grey to ochraceous, thin, indistinctly surrounded by dark hypothallus, crustaceous, areolate with ± plane and angular areolae usually less than 0·5 mm. diam., K yellow then reddish, medulla I–. Algae green, 8–10 μ diam. Apothecia small, immersed, often lecideoid, becoming partly emergent and with definite thalline margin, at times pruinose, dark. Paraphyses septate, fairly discrete, ± submoniliform especially with K, coherent above. Hymenium blue with iodine (especially asci), then sordid- or wine-reddish. Hypothecium pale or colourless, yellowish with K, with algae below. Spores simple, colourless, 8–11 × 5–6 μ, oblong or ovate with a distinct wall. Ascus broadly clavate, 45–50 × 18 μ. *A. cinerea* has a similar reaction with K, but its spores are much larger and its external appearance is different. An immature plant from Kyles of Bute (100) is somewhat similar but is not definitely determinable.

Psora prostratula (Stirt.) comb. nov. *Lecidea p.* Stirt. in Scott. Nat., v, 218 (1880). Pass of Leny (87*).

Biatora coarctata (Sm.) Th. Fr. Balthayock Woods (89*), Stornoway (110*); var. *elachista* (Ach.) Th. Fr., Stornoway (110*); form *depauperata* Leight., Killin (88*), is a form not hitherto recorded from Scotland.

B. granulosa (Ehrh.) Mass. Dalwhinnie (96*), Stornoway and Garrynahine (110*).

B. valentior (Nyl.) Wats., Lich. Not. V. Mts. of Lismore (I. 6*). Apparently collected from wet rocks as *Aspicilia lacustris* is present. The thallus is whiter and better developed and the apothecia are darker than in my Scottish specimen from Ardlui, which is almost identical with the original specimen from Galway. The darker apothecia indicate *B. indigula* (Nyl.) comb. nov. (= *Lecidea indigula* Nyl., in Flora, lx, 563, 1877), which

was obtained from a schistose stone of a wall. This is an uncertain, and therefore unreliable, habitat, as the stones of the wall may have come from rocks at higher altitudes or wetter places. If the wall-stone came from a wet habitat it is quite probable that *B. valentior* and *B. indigula* are the same species, the slight differences being due to the transference of the specimen, to which the latter name was given, to a dry habitat, where greater exposure to illumination and evaporation may have caused a darkening of the apothecia and other changes. It is not uncommon to find altered or impoverished plants from high altitudes or wetter habitats occurring on the stones of a wall at a lower altitude or in a drier situation.

B. Bauschiana Krb. Near Perth (88*), Glen Tilt (89*), W. Smith, 1891.

B. Gagei (Sm.) comb. nov. (= *Lecidea Gagei* Sm.). Stornoway (110*).

B. Casimiri Müll-Arg. On siliceous rock, Kinnoull Hill (89*), 1856. As this is new to the British Isles the following description is given. Thallus greyish-white, plane, areolate, K+yellow, C–, KC–, I–, with protococcoid algae, limited by dark hypothalline lines. Apothecia small, innate, dark, when moistened with a brownish or even reddish tinge, epruinose. Hymenium bluish with iodine, then dark tawny. Paraphyses subdiscrete or subcoherent, somewhat brownish above (yellowish after K). Asci clavate, 30–40 μ long, apparently with the wall thickened above, often with an undeveloped sporal mass, but when spores are developed they are simple, eight, colourless, firm-walled, 7–9(–11) $\times$ 4–5 μ and blunt at the ends. Mr. Lamb, who agrees with this conditional determination, has endeavoured to obtain the original specimen from herb. Boissier at Geneva for comparison, but apparently it is lost. Müller unfortunately never mentioned chemical reactions in his descriptions as he did not believe in their use.

Lecidea protrusa Fr. Loch Straven (98*).

L. latypea Ach. Stornoway and Garrynahine (110*).

L. leucophaea (Flk.) Nyl. Ben Ledi and Pass of Leny (87*), Dalwhinnie (96*).

L. viridiatra (Stenh.) Schaer. West Lomond Hill (85*).

L. lapicida Ach. This name, as used in A. L. Smith's Monograph, includes plants which vary in regard to the coloration of the thallus with potassium hydroxide, and also in regard to the colour of the hypothecium. The latter is rather variable, but in thin section is usually pale brownish. In a restricted sense *L. lapicida* Ach. refers to the plant with a negative coloration with potassium hydroxide, and the following records refer to this plant: Ben Ledi (87), Loch Tay and Ben Lawers (88), W. Smith, Glen Callater (92), Garrynahine (110). Form *plumbescens* (Nyl.) Vain., which is new to the British Isles, differs from the type in the colour of the thallus, which is mostly dark grey but with some ochraceous patches. Ben Lawers (88), Glen Callater (92*), Garrynahine (110*).

L. pantherina (Ach.) Th. Fr. is similar to *L. lapicida*, but its thallus with potassium hydroxide becomes yellow and then red. Ben Ledi (87), Ben Lawers (88), Lerwick (112); form *hypophaeiza* Vain., summit of Ben Ledi (87*), 1859, is new to the British Isles, the thalline areolae are convex or rugose, the apothecia are epruinose, whilst the hypothecium varies from pale brown to dark brown; form *oxydata* (Krb.) Anzi, with thallus more or less ochraceous, is also new to the British Isles, Ben Nevis (97*).

L. lactea Flk. Top of Ben Ledi (87*), Lerwick (112). This is *L. pantherina* var. *lactea* Vain. Adj. Lapp. II (1883), 57. The medullary reaction with iodine is not mentioned in British lichenological works, but it is present in all specimens of *L. lactea* which I have collected, and in correctly determined material from various herbaria which I have examined. The hypothecium in *L. pantherina* is usually paler, but all intermediate shades to the dark brown colour in that of *L. lactea* can be observed. Vainio is therefore justified in reducing the plant to the status of a variety in which the "apothecia are more or less pruinose at first and the hypothecium more or less dark brown below." Scottish specimens, named *L. lactea*, collected by Wheldon and Wilson from Ben Lawers, Ben More, Tarmachan, Am Binnian, Gleneagles and banks of Tummel, all in v.c. 88, have the medullary hyphae coloured blue with iodine. According to Vainio, Lich. Fenn., iv, the plant known as *L. declinans* Nyl. has

no reddish coloration of the thallus to potassium hydroxide, and it is therefore a corresponding form of *L. lapicida* with a darker hypothecium than is usual in the type. *L. lapicida* var. *declinans* of A. L. Smith (Mon. 1926) seems to belong to *L. pantherina* var. *lactea*. It is quite probable that *L. subkochiana* Cromb. is merely another form of *L. pantherina*.

L. tessellata Flk. Ben Lawers (88). The relationship of this species to *L. lapicida* is a very close one. According to Vainio it differs chiefly in the more innate apothecia, which are somewhat pruinose at first.

L. lulensis Hellb. (*L. leucophaeoides* Nyl.). Ben Ledi (87*). New to Scotland.

L. mesotropoides Nyl. Dalwhinnie (96*).

L. mesotropa Nyl. Summit of Ben Ledi (87*).

L. lithophila Ach. Craig Spardon (90*) W. Smith, Stornoway (110*); form *ochracea* (Ach.) Nyl., Dalwhinnie (96*).

L. rivulosa form *depressa* Leight., Stornoway (110*).

L. Kochiana Hepp. Ben Ledi (87*).

L. griseoatra (Hoff.) Schaer. A specimen from Dalwhinnie (96) is peculiar, as the thallus is much paler than usual.

L. panaeola form *subconsentiens* Leight. Pass of Leny (87*).

L. contigua form *Hoffmanni* Leight. Ben Ledi (87*), Stornoway (110*); var. *flavicunda* (Ach.) Nyl., Ben Nevis (97*), Coruisk, Skye (104*), Mts. of Lismore (I. 6*), Moore.

L. percontigua Nyl. Craig Spardon (90*) W. Sm., Garrynahine and Stornoway (110*); form *pruinosa* Wh. & Hart., Abernethy (88*) is new for Scotland.

L. sorediza Nyl. Cathlie (90*) W. Smith.

L. crustulata (Ach.) Krb. Garrynahine and Stornoway (110*); form *geographica* Cromb., summit of Ben Ledi (87*); var. *meiospora* (Nyl.) Oliv., Dunning (88), near Perth (89*).

L. albocoerulescens (Wulf.) Ach. Dalwhinnie (96*), Stornoway and Garrynahine (110*); var. *alpina* Schaer., Ben Lawers (88) W. Smith, Lerwick (112*). According to A. L. Smith's Monograph, 1926, all previous British records of this variety were transferred to *L. phaeenterodes* Nyl. with an orange-red thalline coloration with K. This cannot be correct, since they had a negative thalline reaction with K (*sec.* Monograph, 1911). Vainio in Lich.

Fenn., iv (1934), states that Nylander's original specimen of *L. phacenterodes* is sorediate, and he includes it as a form of the plant he calls *L. soredizodes*. He retains *L. albocoerulescens* var. *alpina*, and states that there is no reaction with K for either.

L. flavocoerulescens (Horn.) Ach. Top of Ben Ledi (87*). This is similar to *albocoerulescens* with a "flavicund" thallus.

L. scutellata Wats. Ben Ledi (87*).

L. confluens (Web.) Ach. form *minor* Leight., Dalwhinnie (96*).

L. cinerascens (With.) A. L. Sm. Var. *elevata* Lynge, Lich. Nova Zembla, Glen Feshie (96*) W. Sm. (1887), with apothecia 0·5–0·7 mm. diam. and more elevated; is new to the British Isles.

L. sublatypea Leight. (=*L. vorticosa* Krb.). Pass of Leny (87*), Dalwhinnie (96*).

L. contiguella Nyl. Ben Lawers (88*)·W. Sm.

L. auriculata Th. Fr. Dalwhinnie (96*), Stornoway (110*).

L. dealbatula Nyl. Kinnoull Hill (89*) W. Smith, with thallus darker than usual.

L. deparcula Nyl. Ben-y-Glo (89*) W. Smith, 1891.

L. fuscoatra (L.) Ach. West Lomond Hill (85*).

L. fuliginosa Tayl. Dalwhinnie (96*).

L. sylvicola Flot. Dalwhinnie (96*).

Pertusaria amarescens Nyl. Garrynahine (110*). New for Scotland. *See* J. of Bot. (1939).

P. pertusa (L.) Tuck. f. *rupestris* DC. Morrone (92*), 1856, Craig Spardon (90*) W. Sm.; var. *leiotera* (Nyl.) Zahl., Glen Almond (88*) W. Smith, 1891, is new to Scotland.

P. ceuthocarpa (Sm.) Turn. Stornoway (110*), Craig Spardon (90*) W. Sm.

P. concreta Nyl. Garrynahine (110*), Lerwick (112*).

P. inquinata (Ach.) Th. Fr. Blackcairn Hill (85*); f. *nolens* (Nyl.) Boist, between Sligachan and Portree, Skye (104*), is a form new to Scotland.

Acarospora smaragdula (Wahl.) Mass. Dalwhinnie (96), Stornoway (110*).

A. fuscata (Schrad.) Th. Fr. Cathlie (90*) W. Sm. Dalwhinnie (96).

A. Normanii Magn. Craig Spardon (90*) W. Sm.

A. veronensis Mass. (=*A. discreta* (Ach.) Th. Fr.). Lerwick (112*).

A. atrata Hue. Stornoway (110*).

Ramalina cuspidata (Ach.) Nyl. Dumfries (72*), Stornoway (110*).

Lecania prosechoides (Nyl.) Oliv. (=*Lecanora helicopis* Ach.). Loch Straven (98), Stornoway (110*).

Biatorina baeomma var. *glaucocarnea* (Nyl.) A. L. Sm. Lerwick (112*). New to Scotland.

B. graniformis (Naeg.) A. L. Sm. Balmerino (85*) W. Sm.

B. Griffithii (Sm.) Mass. Red Head (90*) W. Sm.

B. lenticularis (Ach.) Krb. Garrynahine (110*); var. *chloropoliza* (Nyl.) A. L. Sm. Ben Ledi and Pass of Leny (87*).

Catillaria premnea (Fr.) Krb. Glen Almond (88), Pitlivie Den (90) W. Sm.

Toninia squamulosa (Deak.) Mudd. Ben-y-Glo (89*) W. Sm.

Bacidia umbrina (Ach.) B. & R. West Lomond Hill (85*).

Lecanactis Dilleniana (Ach.) Krb. Reinakyllick (?) W. Sm., 1891.

Placodium callopismum (Ach.) Mer.; var. *plicatum* f. *thallincolum* (Wedd.) Wats., Wormit (85*), a specimen in herb. W. Smith, to which Nylander *in litt* to J. McAndrew gave a new specific name. Form new to Scotland.

Callopisma cerinum (Ehrh.) De Not. Stornoway (110*), 1866; var. *stillicidiorum* (Horn.) Mass., Ben-y-Glo (89*) W. Sm.

C. lacteum (Mass.) Wats. Clapham (64*). Some of the specimens have spores which are tetrastichoid, *i.e.* similar to those of *C. tetrastichum*. Similar forms of spores have been found in *C. lacteum* from Clapham collected by myself, also from Purn Hill (5), Durdham Downs (34), and Rhossili (41).

C. caesiorufum (Ach.) Wats. Stornoway (110*).

Candelariella vitellina (Ehrh.) Müll. Dumfries (72*); var. *aurella* (Hoff.) A. L. Sm., Stornoway (110*).

Pseudophyscia fusca (Huds.) Wats. Stornoway (110*).

Physcia stellaris (L.) Nyl. form *rosulata* (Ach.) Nyl. Corsejethol Woods (48*), Carrington.

P. tribacoides Nyl. Arbroath (90*) W. Sm.

Rinodina atrocinerea (Dicks.) Krb. Stornoway (110*).

R. biatorina Krb. Falls of the Lubnaig in the Pass of Leny (87*), 1859. Mr. Lamb suggested this naming. As it

is new to the British Isles the following description is given. Thallus crustaceous, effuse, areolate, greyish or somewhat sordid or tawny, K– or faint yellowish, C–, I–, with green algae and indistinct hypothallus. Apothecia minute, appressed, when young with slight indication of urceolate form, then plane or slightly convex, epruinose, dark and with margin concolorous or apparently absent, when moistened the disc is somewhat reddened and the margin appears darker, algae sparingly present beneath. Paraphyses subcoherent to subdiscrete, capitate and septate above but often indistinctly so. Epithecium brown. Hypothecium colourless in thin section, yellowish in thick section, with some algal cells beneath. Hymenial gelatine blue with iodine. Spores 8, brown, bilocular or one-septate, sometimes with slight polar caps, blunt at both ends, not constricted or only slightly so, $16–19 \times 8{\cdot}5–10\ \mu$ (*sec.* Th. Fries. Lich. Scand., $19–22 \times 9–11\ \mu$).

Buellia myriocarpa (DC.) Mudd. Ben Nevis (97*); form *areolata* Leight., Barmouth (48*), Carrington.

B. spuria (Schaer.) Krb. Near Perth (89*), Dalwhinnie (96), Stornoway and Garrynahine (110*).

B. verruculosa (Borr.) Mudd. Near Perth (89*), Loch Straven (98).

B. leptocline v. *Mougeotii* (Hepp.) Th. Fr. Top of Ben Ledi (87*), 1867, Dalwhinnie (96*). In the Ben Ledi specimen the thallus has a supplementary reddish coloration with K. This reaction is somewhat similar to that of *B. italica* Mass., which has not yet been recorded from our islands, but the thallus is not milk-white as in that species. The spores are $11 \times 6\ \mu$, and therefore rather small for either species.

B. alpicola (Wahl.) Kremp. Ben Nevis (97). The spores ($15 \times 10\ \mu$) are smaller than usual, the apothecia are less innate and more distinctly marginate, and the colour of the thallus is not such a bright yellow as usual in a typical plant.

B. colludens (Nyl.) Tuck. Top of Ben Ledi (87*). The thallus is rather better developed than usual.

B. confervoides Kremp. Stornoway (110*).

B. badia v. *atrobadia* (Nyl.) A. L. Sm. Dalwhinnie (96*).

Rhizocarpon viridiatrum (Flk.) Krb. Pass of Leny (87*).

R. petraeum var. *excentricum* (Ach.) A. L. Sm. Ben Ledi (87*), Craigie Hill (88), Dalwhinnie (96*); form *coarctatum* (Leight.), Craigie Hill (88*). Form new to Scotland.

R. confervoides DC.; form *albicans* (Flot.) A. L. Sm. Garrynahine and Stornoway (110*), Lerwick (112*); f. *dispersum* (Leight.) A. L. Sm., top of Ben Ledi (87*), top of Dunlan Ridge (96*), Garrynahine (110); f. *coracinum* (Flot.) A. L. Sm., Lerwick (112*); f. *fuscescens* (Leight.) A. L. Sm., Garrynahine and Stornoway (110*), Lerwick (112*).

R. obscuratum form *ferratum* (Nyl.) A. L. Sm. Craig Spardon (90*) W. Sm.

R. plicatile (Leight.) A. L. Sm. Near Perth (89*), is not too definite in regard to some of the varying characters of this species.

R. geminatum Krb. (= *R. disporum* (Naeg.) Muell.-Arg.). Kinnoull Hill (89*).

Cladonia furcata var. *palamaea* (Ach.) Nyl. Maol Ghaordi (88*), Anon.

C. Floerkeana v. *carcata* (Nyl.) Vain. Chapel Fell, Weardale (66*) W. Johnson.

Petractis clausa (Hoff.) Kremp. Glen Lochay (88*) W. Smith.

Crocynia lanuginosa (Ach.) Hue. Dumfriesshire (72). The var. *albescens* B. de Lesd. in herb. W. Smith is not a lichen but of animal origin.

Collema cheileum form *nudum* (Sch.) Leight. I. of Portland (9*) E. M. Holmes.

Synechoblastus Laureri Flot. Foot of Ben Lawers (88*). New to Scotland.

Dirina repanda (Fr.) Nyl. A specimen collected in 1862 by Larbalestier from Noirmont, Jersey, is like this in many respects, but its apothecia are pale reddish-brown and its spores are shorter ($10 \times 3\ \mu$). It is probably an undescribed species or a mutant which has not succeeded in establishing itself.

Arthonia gregaria var. *astroidea* (Leight.) Mudd. Yorkshire (64*), Carrington.

A. radiata var. *Swartziana* (Ach.) Sydow. Buckland Farrington (22*) Mrs. Milne.

A. punctiformis Ach. Buckland Farrington (22*) Mrs. Milne.

A. varians (Dav.) Nyl. (=*Celidium varians* Arn.). Lerwick (112).

Allarthonia phaeobaea (Norm.) Zahl. (=*Arthonia paralia* Nyl.). Stornoway (110*). New to Scotland.

Lithographa tesserata (DC.) Nyl. Top of Ben Ledi (87*).

Melaspilea lentiginosa (Lyell) Zahl. New Forest (11) C. Lyell is a type or co-type specimen.

Opegrapha atra Pers. Buckland Farrington (22*) Mrs. Milne; var. *denigrata* (Ach.) Schaer., Buckland Farrington (22*) Mrs. Milne.

O. betulina Sm. Pitlivie (90*) W. Sm.

O. saxicola Ach. Stornoway (110*).

O. calcarea Turn. Lunan (90*) W. Smith.

O. confluens Stiz. Near Berwick (81*), Oban (98) W. Sm.

O. varia f. *diaphora* Ach. Glen Clunie (92*) W. Sm.

Graphina anguina (Mont.) Müll. Broughty Ferry (90*), 1856.

Cyphelium stigonellum (Ach.) Zahl. Dalwhinnie (96*), Garrynahine (110*).

Verrucaria maura Wahl., var. *memnonia* Wedd. (=*V. pseudomemnonia* Zsch.). St. Columb (1*) E. M. Holmes, Stornoway (110*).

V. aethiobola Wahl. Dunkeld (89*).

V. viridula (Schrad.) Ach. Stornoway (110*).

V. coerulea DC. Pass of Leny (87*), Lerwick (112*).

V. collematodes Garov. Lerwick (112*). This has not hitherto been recorded from the British Isles. A plant collected on granitic rock in 1866 has some likeness, in its dry condition, to a form of *V. macrostoma*, but its spores are small ($15–19 \times 7–8\ \mu$). It agrees in many respects with the critical *V. collematodes* in forming a more or less collemoid mass when moistened, though the brown areolae remain rather distinct.

V. mutabilis Borr. Between Grantully and Dalguise (88*).

V. prominula Nyl. Stornoway (110*). New to Scotland. Var. *minor* A. L. Sm., and var. *viridans* Nyl., also new to Scotland. Stornoway (110*).

Polyblastia subinumbrata (Nyl.) A. L. Sm. Glen Lochay (88*) W. Sm. Not previously recorded from Scotland. It has the appearance of *P. scotinospora* (Nyl.) Hellb., but its spores are smaller and have four transverse septa instead of eight.

Arthopyrenia analepta (Ach.) Mass. On birch from 85* or 88, *leg.* W. Smith as *A. epidermidis.*

A. punctiformis (Pers.) Arn. Balmerino (85*), W. Smith, as *A. epidermidis.*

Coriscium viride (Ach.) Zahl. Top of Ben Ledi (87).

The following fungi parasitic on lichens were noticed:—

Didymella epipolytropa (Mudd) B. & V. Dalwhinnie (96*).

Discothecium gemmiferum (Tayl.) Vouaux. Ben Ledi (87*), Craig Spardon (90*) W. Smith, Loch Coruisk (104).

Pharcidia epicymatia (Wallr.) Wint. Near Perth (89*).

Tichothecium pygmaeum Krb. Craig Spardon (90*) W. Smith.

The Mosses of Barra, Outer Hebrides. By E. Vernon Watson, B.Sc., Ph.D. (With Pls. XLII–XLIII.)

(Read 15th June 1939.)

Introductory.

During the latter half of the nineteenth century the island of Barra was visited from time to time by botanists, who made certain observations on the general character of the flora. These early observations, however, took the form of notes on specific rarities (12) rather than that of anything approaching a comprehensive survey. Furthermore, the higher plants comprised the primary object of inquiry, and it appears that the Bryophyta received comparatively little attention. Thus, when Barra was visited by the Edinburgh University Biological Society in July 1935, it was found that the mosses presented almost a virgin field for investigation. In the report issued in 1936 a list of the mosses obtained on that occasion appeared, which included a number of new vice-county records (2). Since 1935 some further and more intensive work has been carried out by the writer on the moss flora of Barra—in July 1936 and in April 1938. The result of these two visits has been to add greatly to the list of species hitherto known to occur on the island. These studies have also made possible an approximate estimate of the distribution of individual species, observations on the vernal aspect of the vegetation obtained in the month of April being particularly valuable from the standpoint of correcting impressions which might have been formed as a result of studying the vegetation at only one season of the year.

It is impossible to offer at present any detailed account of the ecological relationships of the various moss communities on Barra. The recognition, however, of a series of distinct habitats, each with its particular group of species, was no difficult matter after some intensive collecting and field observation had been undertaken. A statement of the existence of certain recognisable communities is therefore

included, and wherever accurate information can be given, notes on habitat are appended to the species in the systematic list.

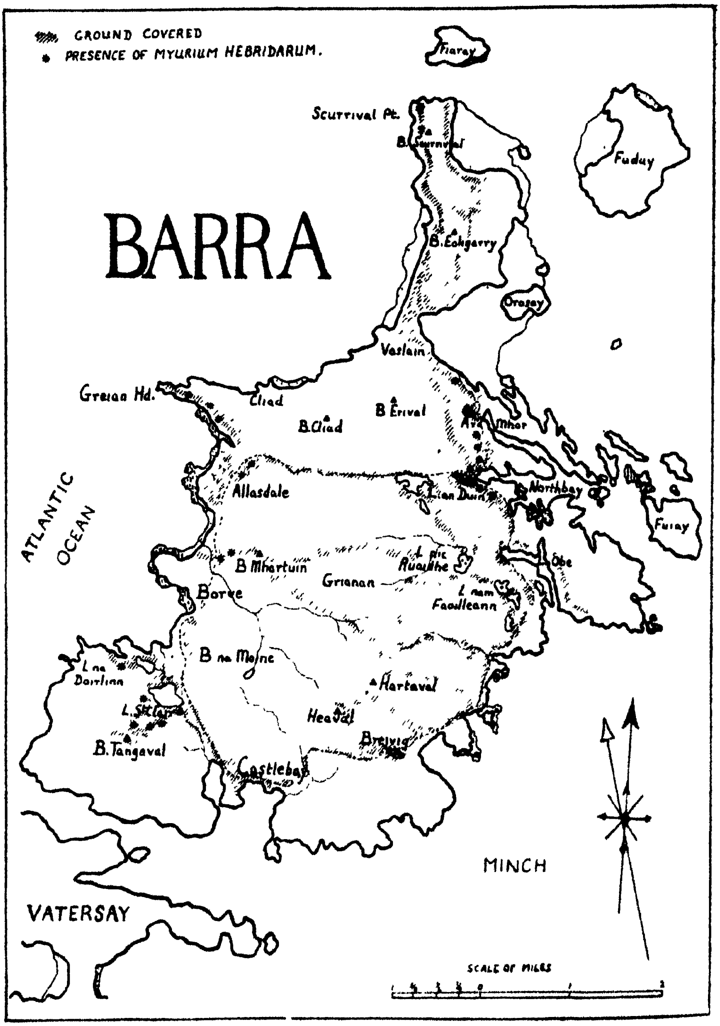
Descriptions of the topography of Barra have already been published (2, 5), and it is unnecessary to present a repetition of these in any detail. Situated near the southern extremity of the Outer Hebrides, the island is about eight and a half miles long and some five to six miles broad at its broadest point. The general configuration and coastline, together with the abundance of small islets off certain parts of Barra, are illustrated on the accompanying map. A great part of Barra consists of undulating moorland, rising to a number of peaks several hundred feet in altitude, Heaval (1260) being the highest point on the island. The peat-covering of this moorland is repeatedly broken by protruding slabs of gneiss rock. On the west coast sand-dunes occur, especially at Allasdale, Vaslain, and Eoligarry: the sand, which consists largely of the comminuted shells of marine organisms, is remarkably white in appearance and alkaline in reaction. A large proportion of the ground, particularly in the hills, is comparatively wet, providing a habitat for Sphagnum and associated types, although the numerous streams are all of small size. Several freshwater lochs provide an aquatic environment which is, however, of less importance for mosses than it appears to be for flowering plants. Indeed there were few species of moss associated with any of the larger expanses of fresh water which did not also occur on small patches of boggy land, wet ledges, or the banks of streams.

The woodland on Barra, which consists of plantations at Northbay and Breivig and a cluster of trees at Ard Mhor, is of very limited extent, but is sufficient to exert a distinct influence on the moss flora, by the introduction of the epiphytic habit, in addition to providing moist and shady conditions ideal for the growth of a wide range of species.

Various human activities on the island are not without their effect on the bryophytic flora, outstanding among the habitats arising in this way being stone walls and the surfaces of freshly cut peat, each capable of supporting a highly characteristic group of mosses.

From the foregoing remarks it will be clear that by far the most extensive areas which are in part colonised by mosses

are stretches of moorland peat, gneiss rock surfaces, and ledges associated with the steeper hill slopes, while only in



certain parts of the island do special conditions obtain which make possible the development of other groups of species. It is the purpose of the account which follows to present an idea of the composition—frequently highly characteristic—of the different moss communities which can be recognised.

PART I.

COMMUNITIES OF MOSSES ON BARRA, WITH NOTES ON THEIR ECOLOGICAL SIGNIFICANCE.

A. *Classification of Communities.*

The difficulties of forming a satisfactory subdivision or classification of habitat types in connection with bryological work have been appreciated by numerous workers in this field. Within the woodland association Richards (10) found it necessary to recognise several entirely distinct moss communities. Watson (16) has described moss associations on wet peat which are completely different from those developed on well-drained peat cuttings which are in the process of regeneration (9). Again the importance of hydrogen-ion concentration has been stressed by numerous observers (4, 7), and lists have been compiled of typical calcicole and calcifuge species (6, 17). Within a single major association of flowering-plant vegetation it may thus become necessary to recognise a number of distinct moss communities.

A further complication arises in the satisfactory demarcation of one habitat from others closely approximating to it. Thus, "wet" and "dry" peat may be found to support distinct groups of mosses, but it becomes impossible to separate the wettest peat surfaces from true submerged habitats, while "dry," thin peat at the edge of rock slabs passes over gradually into the rock surface itself. Indeed, only when they can be viewed in the light of a knowledge of their rôles in plant succession can the different moss communities be understood (3, 8, 14); and because this fact is realised the classification of communities which follows is only tentatively submitted.

Recognising the nature of the substratum as of fundamental importance, the following habitats may be distinguished on Barra:—

A. *Sand.*

1. Blown sand of unfixed dunes.
2. Sand of fixed dunes.
3. Sand-filled crevices among rocks.
4. Wet sand at edge of streams near sea.

B. *Peat.*

5. Bare surfaces of artificially cut peat.

6. Wet peat ledges on steep slopes.

7. Thin peat, usually comparatively dry, at edge of rock slabs.

8. Wet peat, mosses in closed association with flowering plants.

9. Peat bog, mosses typically submerged, at least in part.

10. Peat humus, mosses in closed association with flowering plants, the latter on peat, the former generally on a superficial humus layer.

C. *Rock (chiefly Gneiss).*

11. Dry rock surfaces.

12. Wet rock surfaces, generally near running water.

13. Rocks submerged in running water.

14. Rocks, margins of still water.

15. Stone walls.

D. *Miscellaneous Soils.*

16. Gravelly glacial deposits, etc., at foot of steep slopes.

17. Steep (often overhanging) moist banks on borders of fixed moorland association.

18. Loam banks, borders of cultivation.

19. Marshes and edges of pools, other than those on peat or sand.

E. *Trees, Stumps, and Fallen Wood.*

20. Stumps, fallen branches, and bases of trees, in shade and moisture.

21. Trunks and branches of trees, removed from ground and constituting true epiphytic habitat.

The following table shows that each of these habitats, as represented on Barra, supports a fairly distinct moss community, with different characteristic species. The term "characteristic" is employed here to designate those species most typically associated with each habitat. The great extent of local variation, together with the different appearances resulting from seasonal changes, combine to render impracticable the designation of any particular species as "dominant" in the majority of community types described. In the few cases where dominance can be recognised conclusively the letters d. (dominant) and l.d. (locally dominant) are employed in the table.

Table of Principal Moss Communities on Barra.

Habitat.	Characteristic Species.	Other Species.
	A.	
1. Blown sand of unfixed dunes.	*Tortula ruraliformis* d.	*Barbula convoluta*
2. Sand of fixed dunes.	*Camptothecium lutescens* d. *Ditrichum flexicaule* *Brachythecium albicans* *Cylindrothecium concinnum*	*Hypnum cupressiforme* *Hylocomium triquetrum* *Hylocomium squarrosum*
3. Sand-filled crevices among rocks	*Weisia verticillata*	*Trichostomum mutabile* *Trichostomum crispulum* *Bryum pseudo-triquetrum* *Amblystegium filicinum*
4. Wet sand at edge of streams near sea	*Pottia Heimii* *Barbula tophacea*	*Ceratodon purpureus* *Amblystegium filicinum* *Eurhynchium striatum* *Hypnum stellatum*
	B.	
5. Bare surfaces of artificially cut peat	*Polytrichum gracile* *Webera nutans*	*Ceratodon purpureus* *Dicranella heteromalla* *Funaria hygrometrica* *Campylopus* spp.
6. Wet peat ledges on steep slopes	*Funaria ericetorum* *Funaria Templetoni* *Hypnum revolvens* *Hypnum scorpioides*	*Ceratodon purpureus* *Dicranella heteromalla* *Blindia acuta* *Bryum alpinum*
7. Thin peat, usually comparatively dry at edge of rock slabs	*Polytrichum juniperinum* *Polytrichum piliferum* *Rhacomitrium lanuginosum* l.d.	*Campylopus fragilis* (many others occasionally)
8. Wet peat, mosses in closed association with fl. plants	*Polytrichum commune* l.d *Campylopus Shawii* l.d. *Campylopus atrovirens* l.d. *Leucobryum glaucum* *Aulacomnium palustre*	*Campylopus* spp. *Hypnum Schreberi* *Hypnum cupressiforme* *Hypnum cuspidatum*
9. Peat bog, mosses typically submerged, at least in part	*Sphagnum* spp. d.	*Campylopus* spp *Hypnum revolvens* (forma) *Hypnum sarmentosum*
10. Peat humus, mosses in closed association with fl. plants, the latter on peat, the former generally on superficial humus layer	*Brachythecium purum* *Hypnum Schreberi* *Hylocomium splendens* *Dicranum scoparium*	*Mnium hornum* *Thuidium tamariscinum* *Hylocomium squarrosum* *Hypnum cupressiforme*
	C.	
11. Dry rock surfaces	*Grimmia pulvinata* *Rhacomitrium fasciculare* l.d. *Ptychomitrium polyphyllum* l.d.	*Campylopus fragilis* *Grimmia trichophylla* *Grimmia apocarpa* *Rhacomitrium* spp. *Hypnum cupressiforme*

Habitat.	Characteristic Species.	Other Species.
Dry rock surfaces —*contd.*	*Camptothecium sericeum* *Orthotrichum rupestre* *Andreaea* spp. (high) *Grimmia maritima* (sea-level) l.d.	*Eurhynchium myosuroides* *Ulota phyllantha* (sea-level, w.co.)
12. Wet rock surfaces, generally near running water	*Blindia acuta* l.d. *Zygodon Mougeotii* l.d. *Hyocomium flagellare*	*Rhacomitrium aciculare* *Campylopus* spp. *Hypnum molluscum* *Hypnum cuspidatum*
13. Rocks submerged in running water	*Fontinalis antipyretica*	*Rhacomitrium aciculare* *Eurhynchium rusciforme*
14. Rocks, margins of still water	*Cinclidotus fontinaloides*	*Grimmia apocarpa* *Rhacomitrium aciculare* *Brachythecium plumosum* *Hypnum cuspidatum*
15. Stone walls	*Trichostomum mutabile*	*Campylopus fragilis* *Ptychomitrium polyphyllum* *Tortula muralis* *Barbula unguiculata*
	D.	
16. Gravelly glacial deposits, etc., at foot of steep slopes	*Ditrichum homomallum* *Dichodontium pellucidum* *Barbula spadicea* *Bryum filiforme*	*Dicranella squarrosa* *Campylopus fragilis* *Philonotis fontana* *Bryum pallens* *Bryum pseudo-triquetrum*
17. Steep (often over-hanging) moist banks on borders of fixed moor-land association	*Fissidens osmundoides* *Breutelia arcuata* *Myurium Hebridarum* *Neckera crispa* *Pterygophyllum lucens*	*Fissidens* spp *Mnium hornum* *Mnium punctatum* *Mnium undulatum* (*Thuidium*, etc., merging into 10)
18. Loam banks, borders of cultivation	*Weisia viridula* *Eurhynchium praelongum*	*Fissidens bryoides* *Fissidens taxifolius* *Funaria hygrometrica* *Bryum capillare* *Mnium hornum* *Plagiothecium denticulatum*
19. Marshes and edges of pools, other than those on peat or sand	*Hypnum cuspidatum* d.	*Hypnum stellatum* *Hypnum falcatum* *Hylocomium squarrosum* *Amblystegium filicinum* (others occasionally)
	E.	
20. Stumps, fallen branches, and bases of trees, in shade and moisture	(No truly characteristic sp.)	*Eurhynchium myosuroides* *Brachythecium rutabulum* *Hypnum cupressiforme*
21. Trunks and branches of trees; true epiphytic habitat	*Ulota phyllantha* d. *Ulota crispa* *Orthotrichum* spp. *Cryphaea heteromalla*	*Hypnum cupressiforme* (especially var. *filiforme*) *Brachythecium rutabulum*

B. *Discussion with Reference to Particular Environmental Factors.*

The type of classification submitted in the above table may be not without value in serving to indicate the principal moss communities on Barra, but its shortcomings in two important respects are obvious. Firstly, it is impossible by the employment of rigid categories to present an adequate account of the concentration of species on ledges and steep slopes generally; and secondly, account must be taken of the significance of such environmental factors as light and altitude, which tend to become critical in determining the *local* distribution of particular species or groups of species.

Steepness of Slope.—The importance of steep slopes in the provision of available habitats for mosses has long been recognised (13), and where slopes of sufficient steepness are amply supplied with moisture and provided with an abundance of ledges and crevices, the latter provide conditions whereby the slopes become populated by species with very different specific requirements. Hence, in the present instance to catalogue the mosses growing in relatively close proximity on slopes would be to include under a single head representatives of nearly half the total number of habitat classes in the table.

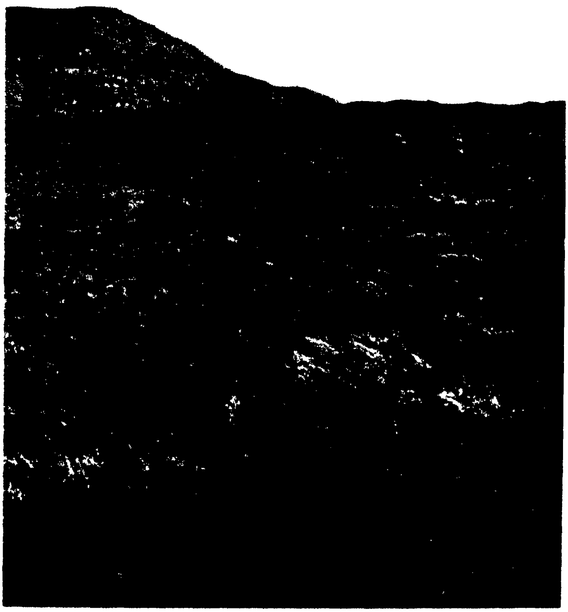
In favourable parts of the west coast of Barra it was possible to find the typical species of wet rock, wet peat, peat humus, gravel deposits, and other habitats all in the closest proximity, but each moss colony actually grew in its particular specialised niche. Steep slopes and wet ledges must thus be regarded, not as one habitat, but rather as an aggregation of habitats, where species of such diverse requirements as *Zygodon Mougeotii*, *Hylocomium squarrosum*, *Funaria ericetorum*, *Fissidens adiantoides*, *Rhacomitrium aciculare*, and *Hypnum molluscum*—to mention a few characteristic types—may occupy adjoining spaces owing to the variety of available surfaces provided. In this way species recognised as calcicoles (17) (*Hypnum molluscum*, *Amblystegium filicinum*, etc.) were found at times associated with markedly calcifuge types, a circumstance doubtless explained by the heterogeneous composition of the substratum.

Light.—The most pronounced effect of deficient light supply

consisted of the exclusion of all save a few species from situations of deep shade. One species, however, *Pterygophyllum lucens*, was confined to these situations, while such a habitat was not inimical to *Blindia acuta*, and species belonging to the genera *Fissidens* and *Mnium*. In a general way partial shade, with its corollary conservation of moisture, led to increased luxuriance of growth. This was especially evident in Northbay plantation.

Altitude.—The moss flora of any given habitat, as classified in the above table, showed a somewhat different composition on the highest ground in Barra from that found at sea-level. To determine the precise distribution of species with reference to altitude would require a separate special investigation (*cf.* 18), but obvious at first sight were the concentration of *Andreaea* species near the hill summits and the restriction of *Grimmia maritima* to the coastal fringe. The question is, however, intimately bound up with that of maritime influences, since no moss growing within a few hundred feet of sea-level on the west coast of Barra can be immune from a very considerable impregnation of salt spray. Indeed, throughout the west and north of the island—where slopes are fully exposed to westerly gales—a characteristic moss flora tended to appear. Not only was *Grimmia maritima* especially abundant in this zone, but *Ulota phyllantha* frequently appeared on the west coast as a rock species associated with species of *Grimmia* and *Rhacomitrium*. Furthermore, *Ptychomitrium polyphyllum* (on rocks), and *Myurium Hebridarum*, *Breutelia arcuata*, and others (on ledges), were confined to these rich northern and western slopes and tended to disappear at the highest altitudes.

Sand Inundation.—Since considerable quantities of sand must be blown in the course of heavy gales beyond the limits of the dunes, the wealth of species occurring on the west coast of the island may be in part attributed to the effect of this calcareous sand. A striking case was provided by *Weisia verticillata*, which appeared to be almost entirely restricted to rock crevices which had become filled with sand blown up in this manner on to the cliff-top at Greian Head and elsewhere, and retained in a constantly fairly moist state through repeated inundations of rain or spray.



General view of moorland east of B. Mhartuin, showing tussocks (of dead *Calluna*) covered with felt-like growth of *Rhacomitrium lanuginosum*.

E. Vernon Watson.

Relationship to Flowering-plant Communities.

The relationship of mosses to the closed associations of flowering plants is stressed in the table, since it is felt that a very real difference exists between the ecological significance of mosses which typically colonise free surfaces and that of those capable of growing in what ordinarily may be described as a closed association of flowering plants (*cf.* 3, 8).

Although in the far north mosses are known to play a dominant rôle in the vegetation, and special investigations have revealed the importance of *Rhacomitrium lanuginosum* (11) and others in this respect, the island of Barra presents few instances where the bryophytes tend to replace flowering plants in a fixed community. Their importance in the initial stages of succession is, however, undeniable, and abundant illustration of this was provided on Barra. *Tortula ruraliformis* on sand, *Rhacomitrium fasciculare* and *R. aciculare* on rock, and *Ceratodon purpureus* and others on peat cuttings, are but a few outstanding examples of mosses as initial pioneers in different serial successions. By contrast it was seldom that a swampy area constituted true Sphagnetum or that species of *Campylopus* formed more than intermittent patches among the Angiosperms of wet moor.

In a few instances strikingly exceptional developments were observed. One case, which was specially investigated, was that of a broad saddle of moorland east of B. Mhartuin. Here tussocks of dead or dying Calluna were separated by narrow boggy channels, and while the former were almost completely covered with felt-like growths of *Rhacomitrium lanuginosum*, the vegetation of the channels consisted principally of lush beds of *Sphagnum* spp. and *Campylopus Shawii* (fig. 1). Flowering plants played an entirely subordinate part in the bryophytic community. Over wide areas of moorland *Rhacomitrium lanuginosum* was either scarce or absent, but there were certain other localities, invariably on high ground, where it became of major importance. A notable instance was provided by the summit of B. Tangaval, where this moss was regarded as a co-dominant with certain flowering plants on the exposed rocky tableland.

PART II.

Systematic List, with Notes on Distribution of Species.

The three collections made, in 1935, 1936, and 1938, have together resulted in a total of 153 species being identified, while in a few cases additional varieties have been obtained. It cannot be claimed that much of outstanding systematic or phytogeographical interest has appeared, but the fact that 68 of the forms here listed are not indicated for vice-county 110 in the Census Catalogue of 1926 (1) indicates the extent to which Barra has presented a field hitherto unworked by bryologists.

The most noteworthy species found is without doubt the rare *Trichostomum hibernicum*, which is known from very few localities in the British Isles outside its principal centre of distribution in S.W. Ireland. *Cryphaea heteromalla* is a Barra species not found previously in any of the Hebridean islands and of very local distribution in Scotland generally. Some interest also attaches to the prominent part played on Barra in their respective habitats by the two well-known Hebridean mosses with Atlantic distribution—*Myurium Hebridarum* and *Campylopus Shawii*. Special attention has been paid in the present investigation to the distribution of *Myurium* on Barra.

Grimmia pulvinata and *Tortula muralis* are species known to be among the commonest and most generally distributed British mosses, which were remarkable for their great scarcity on Barra.

While in the list which follows an attempt is made (except among Sphagna) to indicate the relative distribution of species, there are numerous cases, such as the genera *Campylopus*, *Barbula*, and *Fissidens*, where two or more closely related species defy separation in the field and where their comparative distribution is accordingly assessed with great difficulty. Furthermore, it is certain that more prolonged and extensive collecting on the island would reveal the presence of other mosses hitherto unrecorded, and necessitate a revision of the accepted status of many of those already known.

The list consists only of the mosses obtained in the present series of collections. It will be seen to omit a few names mentioned in the list published for the island in 1936. These species lack confirmation. Also omitted is the rare maritime moss, *Bryum Marratii*, found long ago on the shores of Barra (12) but not obtained by the present writer. Certain other species known from vice-county 110 cannot as yet be listed for this island.

All species which are believed to be new vice-county records have been confirmed and numerous other critical forms determined by Mr. J. B. Duncan, with the exception of the Sphagna, which were named by Mr. W. R. Sherrin, and *Bryum inclinatum*, which was identified by Mr. H. H. Knight. I am greatly indebted to these bryologists for their valuable assistance.

I would thank Professor W. Wright Smith and members of the staff at the Royal Botanic Garden, Edinburgh, especially Mr. W. Young, Keeper of the Bryological Herbarium, for help and facilities provided at all times in the course of the present work.

Nomenclature.—The nomenclature followed here is that adopted in A Census Catalogue of British Mosses (2nd ed.), 1926 (1). In the case of the Sphagna, Warnstorf's classification is followed (*cf.* Sphagnologia Universalis, 1911) (15).

SPHAGNALES.

Sphagnaceae.

Sphagnum rubellum Wils. Taken once on moorland E. of B. Mhartuin.

**Sphagnum quinquefarium* Warnst. One gathering obtained near L. Obe.

S. plumulosum Roell. Taken several times on high, wet moorland.

**S. squarrosum* Pers. Obtained once from moorland E. of B. Mhartuin.

S. recurvum Beauv. Taken from high moorland between Grianan and Hartaval.

* Not recorded for v.c. 110 in Census Catalogue (1926) or Supplement (1929).

*S. *cuspidatum* Ehrh. var. *plumosum* Bryol. germ. One record, plants growing submerged in pool near Cliad.

*S. *molluscum* Bruch. Found once in same locality as *S. recurvum*.

*S. *obesum* Wils. Taken once on wet ground in Northbay plantation.

*S. *subsecundum* Warnst. Taken on wet ground by road, Northbay.

*S. *auriculatum* Schp. An aberrant form of this species was taken on B. Tangaval.

*S. *crassicladum* Warnst. Taken once on wet moorland among central hills.

*S. *bavaricum* Warnst. Obtained once on wet ground at Northbay.

S. *cymbifolium* Ehrh. Taken on wet ground among hills above Allasdale.

ANDREAEALES.

Andreaeaceae.

Andreaea petrophila Ehrh. Recorded on rocks on high ground, Heaval and Tangaval.

A. Rothii Web. et Mohr. Locally fairly plentiful on boulders at high altitudes; absent from all lower slopes.

BRYALES.

Polytrichaceae.

Polytrichum aloides Hedw. Twice found on exposed peat surfaces in the hills.

P. urnigerum L. Taken twice on wet peat banks near L. nic Ruaidhe.

P. alpinum L. Occurring very locally on high ground on peat.

**P. piliferum* Schreb. Widely distributed on well-drained parts of moorland, growing chiefly on thin peat at edges of rocks.

P. juniperinum Willd. Commoner than the last species, frequenting similar situations.

**P. gracile* Dicks. Found only on April visit, when it appeared to be locally plentiful on peat cuttings in the hills.

P. formosum Hedw. Nowhere abundant, but of wide distribution, occurring not only in Northbay plantation, but also on wet moorland which is more often the habitat of *P. commune.*

P. commune L. Locally abundant on wet moorland in the hills; also found in Northbay plantation.

Dicranaceae.

**Ditrichum homomallum* Hampe. Found only at Allasdale, on wet gravelly soil by road.

**D. flexicaule* Hampe. Occurred plentifully in its typical form on maritime sand at Vaslain; depauperated plants were found at the edge of moorland on the east coast, a most unusual habitat for a calcicole species, and perhaps connected with the impregnation of the peat at sea-level by calcareous sand.

Ceratodon purpureus Brid. Exceedingly widely distributed, occurring on peat, sand, walls, and ledges, in wet and dry situations, but absent from the highest altitudes. The most typical material, fruiting abundantly in April, grew on peat cuttings in the hills. A form occurring on very wet peat was far from typical, with long and narrow, acute leaves.

**Dichodontium pellucidum* Schp. Found only once, with *Ditrichum homomallum* and other mosses on wet ground by road at Allasdale.

var. **compactum* Schp. Occurred with the type at Allasdale.

Dicranella heteromalla Schp. Widespread and locally plentiful on peat cuttings and banks; also occurred on decaying material in Northbay plantation.

**D. squarrosa* Schp. Two small colonies found on rock ledges, one at sea-level and the other at a high altitude between Grianan and Hartaval.

Blindia acuta B. et S. One of the commonest species on some of the steeper hillsides, occurring most plentifully only on wet or shaded rocks. Often deep in the crevices of wet rocks it was the only moss present. Less common at sea-level than at an altitude.

Campylopus Schwarzii Schp. An uncommon species of peat at fairly high levels.

C. flexuosus Brid. A small form was almost invariably among the colonists of peat cuttings in the hills. Elsewhere found occasionally on rocks, a large and luxuriant form being taken on wet ledges on B. Tangaval.

C. pyriformis Brid. Recorded twice on peat surfaces in the hills.

C. fragilis B. et S. Occurring in a wide range of habitats but never abundant. Found most often as small cushions on peat and boulders at all altitudes on moorland; also taken in Northbay plantation.

C. Shawii Wils. Locally abundant in the hills, being found in great plenty and luxuriance over wide areas of damp moorland. Became a dominant feature of the vegetation on the slopes E. of B. Mhartuin, growing with *Sphagnum* spp. in wet hollows between tussocks of partially decayed Calluna scrub which was covered with a felt-like growth of *Rhacomitrium lanuginosum*.

C. atrovirens De Not. The commonest species of the genus, being locally very plentiful. Confined to wet moorland, it grew on boggy ground with *C. Shawii* and others, or on ledges with *Blindia acuta* or *Bryum alpinum*.

C. brevipilus B. et S. Of very local occurrence, on peat surfaces and among flowering plants of moorland.

var. **auriculatus* Ferg. One record of plants growing with *Rhacomitrium lanuginosum* on wet moorland E. of B. Mhartuin.

Dicranum scoparium Hedw. Widely distributed on grassy ledges, occurring at all altitudes but never abundant. Somewhat restricted in range of habitat, being absent alike from pure peat surfaces and maritime sand.

var. *spadiceum* Boul. One record from moorland bank.

D. majus Turn. Occurred in fair quantity on shady bank in Northbay plantation. Also taken from grassy ledge near L. Obe.

Leucobryum glaucum Schp. Taken twice on moorland slopes.

Fissidentaceae.

Fissidens bryoides Hedw. Found in fair quantity on shaded banks in Northbay plantation.

F. osmundoides Hedw. Widely distributed on moist rocky ledges at all altitudes.

F. adiantoides Hedw. Widespread and rather commoner than the last species; found in similar habitats but also taken on marshy ground, growing with *Hypnum falcatum* and other mosses.

F. decipiens De Not. Recorded a few times on wet rocky ledges; apparently scarce.

F. taxifolius Hedw. Occurred widely in rock clefts and on bare soil in deep shade, but never in exposed situations nor at high altitudes.

Grimmiaceae.

Grimmia apocarpa Hedw. On boulders at or near sea-level; of wide distribution but not abundant. Grew on rocks in stream, Northbay plantation.

G. maritima Smith. Occurred in abundance on maritime rocks, rising to an altitude of over 100 feet at Greian Hd. and on B. Scurrival. Less frequent on E. coast, where confined to sea-level.

**G. pulvinata* Smith. Widespread on boulders but never plentiful, and confined to low altitudes.

G. trichophylla Grev. Widespread on boulders; found mainly near sea-level, but taken once on higher ground.

Rhacomitrium ellipticum B. et S. Taken twice on B. Tangaval, on exposed summit and on wet rocks on north slope; also recorded on rocks at Northbay.

R. aciculare Brid. One of the commonest mosses on boulders, but less plentiful on high ground than at sea-level.

**R. protensum* Braun. Occurring locally on rock ledges at high altitudes.

R. fasciculare Brid. A plentiful and widespread rock moss. The commonest Rhacomitrium on much of the high ground, but less so at sea-level; always on boulders and often in the most exposed situations.

**R. heterostichum* Brid. Not uncommon on boulders and widely distributed.

var. **gracilescens* B. et S. Taken occasionally on rock surfaces.

R. sudeticum B. et S. One record, on rocks among central hills.

R. lanuginosum Brid. Abundant on some hill slopes but somewhat local. Reaching full, luxuriant development

on parts of high ground in central hills, it formed dense mats a foot or more in width and became a dominant feature of the vegetation (fig. 1). Elsewhere, especially at low levels, it was far from plentiful.

R. canescens Brid. Taken once on rocks at edge of moorland, Castlebay.

Ptychomitrium polyphyllum Fuernr. The commonest of all boulder species in well-watered situations at low altitudes, occurring in shade of Northbay plantation besides being exceedingly plentiful on exposed rock surfaces and ledges throughout north and west Barra. Scarce on east coast and absent from high altitudes.

Hedwigia ciliata Ehrh. Three records, one on rocks at Castlebay, two on high rock ledges in the hills.

Tortulaceae.

**Pottia Heimii* Fuernr. Taken once only, on wet sand by stream flowing into sea at Allasdale.

**Tortula muralis* Hedw. Very scarce; recorded on four occasions, small colonies being found on walls or boulders at Castlebay, Northbay, Vaslain, and Eoligarry.

**T. ruraliformis* Dixon. Plentiful on maritime sand at Vaslain, Allasdale, and Eoligarry. Frequently the only moss present among scattered flowering plants on loose, blown sand.

**Barbula rubella* Lindb. One record, on maritime sand at Allasdale.

var. **ruberrima* Ferg. Taken once on rocks at Castlebay.

**B. tophacea* Mitt. Grew with *Pottia Heimii* on wet sand at Allasdale.

**B. fallax* Hedw. One record, on bare ground by road at Northbay.

**B. spadicea* Mitt. Taken once, at Allasdale, where it grew with other strictly local species such as *Ditrichum homomallum* and *Dichodontium pellucidum* on damp gravelly soil.

**B. cylindrica* Schp. One record, of a small colony on shaded bank in Northbay plantation.

**B. convoluta* Hedw. Occurred as a scarce species on parts of west coast, colonising loose sand between plants of *Ammophila* and other species.

Trunk of *Acer Pseudo-platanus* in Northbay Plantation, showing extensive epiphytic colonies of *Ulota phyllantha*.

(In the background is seen a typical stretch of terraced moorland.)

E. Vernon Watson.

***B. unguiculata* Hedw. Widespread but scarce. Taken on slopes of Heaval, bank at Castlebay, and wall-top at Eoligarry.

**Weisia viridula* Hedw. Two records only, on walls at Northbay and Castlebay.

**W. verticillata* Brid. Locally plentiful in rock crevices on west coast. At Allasdale on lime-impregnated rock face; elsewhere only where crevices were filled with calcareous sand and rendered moist by rain and spray. A remarkable case of habitat restriction.

**Trichostomum crispulum* Bruch. Scarce and local; occurring like the last species in sand-filled rock crevices, but also taken on shaded boulders in Northbay plantation.

T. mutabile Bruch. Common and widespread. Grew in stunted form on walls, dry ledges and rock surfaces, but reached its best development on wet ledges where it was common except at high altitudes.

var. *littorale* Dixon. Taken several times at sea-level.

**T. hibernicum* Dixon. A plant of exceptional interest taken only on wet ledges on the north slopes of B. Tangaval.

T. tortuosum Dixon. Not uncommon on wet ledges in the west of Barra.

**Cinclidotus fontinaloides* P. Beauv. Taken only on rocks at margin of L. St. Clair, where it was fairly plentiful.

Orthotrichaceae.

**Zygodon Mougeotii* B. et S. A locally abundant species, occurring on wet rock ledges and ascending from near sea-level to the highest ground. Most plentiful on parts of west coast and in shaded gullies in the hills, where it grew in dense cushions which in exceptional cases measured a foot across, the plants nearly six inches in height.

**Ulota crispa* Brid. One record, of a few plants on trees in Northbay plantation.

U. phyllantha Brid. The only abundant epiphytic species, growing extensively on trees at Breivig and Northbay (fig. 2), also locally common on rocks, but apparently confined in this habitat to low altitudes in north and west.

U. Hutchinsiae Hamm. An uncommon species taken occasionally on rocks near sea-level.

**Orthotrichum rupestre* Schleich. Confined to rocks and commonest near sea; widely distributed but in no part abundant.

**O. tenellum* Bruch. One record, of a few plants growing on the trunk of an ash at Vaslain.

**O. pulchellum* Smith. Single record, of a few plants on tree in Northbay plantation.

Funariaceae.

Funaria ericetorum Dixon. A not uncommon species, occurring at all altitudes on bare peaty banks and wet ledges.

F. Templetoni Sm. Similar in range to the last species, but confined to peaty banks.

F. hygrometrica Sibth. Locally plentiful on cut peat in the hills; found in April fruiting abundantly with *Polytrichum gracile* and other mosses. Also recorded on cultivated land by croft.

Me

Aulacomnium palustre Schwaeg. Scarce and very local, occurring occasionally on damp moorland.

Bartramiaceae.

Bartramia ithyphylla Brid. Found once on grassy bank at Northbay.

Philonotis fontana Brid. A scarce species on moorland and wet ledges near sea-level. Recorded five times only, never in quantity.

Breutelia arcuata Schp. Common and widespread on moorland, and especially on wet grassy slopes and ledges. Found at all altitudes, growing in dense tussocks in most favourable parts of west coast.

Bryaceae.

Webera nutans Hedw. Of local occurrence on peat cuttings in the hills.

**W. annotina* Schwaeg. One record from earthy bank.

**W. albicans* Schp. Taken once on bank at Allasdale.

**Bryum filiforme* Dicks. Recorded twice on bare gravelly soil, at Northbay and Allasdale.

**B. inclinatum* Bland. Found only on April visit, when it was taken in fruit on peat cuttings near L. nic Ruaidhe.

B. pallens Sw. Taken on each occasion with *B. filiforme*. Also recorded on rocks at Castlebay.

B. pseudo-triquetrum Schwaeg. Of remarkably wide distribution, although never abundant; occurring in sand-filled rock crevices at sea-level with *Weisia verticillata*, on gravelly soil with *B. filiforme* and others, and on peaty ledges in the highest parts of Barra. On one occasion young plants were found growing within a close cushion of *Trichostomum mutabile* on a rock ledge.

**B. capillare* L. Very scarce; taken on bank near L. Obe and on wall at Castlebay. A form approaching var. *macrocarpum* Huebn. occurred in fair quantity in Northbay plantation.

B. alpinum Huds. Widely distributed on wet peaty ledges and boulders from sea-level to high altitudes, often growing with *Campylopus atrovirens* on the margins of rock surfaces.

var. *viride* Husn. Occurred locally, chiefly in drier situations.

Mnium rostratum Schrad. One record on sand at Vaslain.

**M. undulatum* L. Widespread in moist shady situations, occurring in ground flora of plantations and on shady banks at various altitudes.

M. hornum L. One of the commonest mosses throughout the island; occurring on banks and ledges in all parts and exceptionally on trees, being absent only from boulders and sand; less plentiful on high ground and often represented by stunted growths among flowering plants, but luxuriant colonies were produced in Northbay plantation.

M. punctatum L. Widely distributed in shady situations; also recorded on exposed rock face near summit of Hartaval, where it grew in profusion among *Hymenophyllum* and other plants.

Fontinalaceae.

Fontinalis antipyretica L. Taken only in stream flowing by Northbay plantation.

**F. squamosa* L. Taken once at margin of Lochan nam Faoilleann.

Cryphaeaceae.

**Cryphaea heteromalla* Mohr. One small colony obtained on a tree in Northbay plantation.

Neckeraceae.

**Neckera crispa* Hedw. Of very local occurrence; plentiful on ledges near L. St. Clair; also taken on B. na Moine and B. Mhartuin.

**N. complanata* Huebn. Recorded on rocks, slopes of B. Mhartuin.

Hookeriaceae.

Pterygophyllum lucens Brid. Widespread on high and low ground but always demanding deep shade, and hence restricted often to small patches screened by rocks or overhanging vegetation.

Leucodontaceae.

**Porotrichum alopecurum* Mitt. Recorded twice on shaded rocks, near L. an Duin and on north slope of Hartaval.

Leskeaceae.

Heterocladium heteropterum B. et S. Fragmentary material found among vegetation of the cliff-top at Greian Hd.

Thuidium tamariscinum B. et S. Common and widespread on banks and ledges at all altitudes, but chiefly as a minor component of fairly dense vegetation. Grew in luxuriant patches on shaded banks of Northbay plantation.

Hypnaceae.

Climacium dendroides Web. et Mohr. One record of a fairly extensive growth on wet peaty margin of L. an Duin.

**Cylindrothecium concinnum* Schp. Found only as a sand species, at Vaslain, where it appeared in small quantity among other more plentiful species.

Myurium Hebridarum Schp. The distribution of this exceptionally interesting species is given in greater detail than that of others, since such detailed information may serve to throw light on the question of what features, if any, of the local environment render it especially suited to this species.

Myurium was among the first mosses to attract the eye at Northbay, and subsequent work showed it to be, in its own habitat, among the common mosses of the island. From Northbay, where it grew near sea-level on rocky banks, *Myurium* extended round the coast to L. Obe, east of which point it was not taken. It grew abundantly along the moist banks between Northbay and Vaslain, apparently either selecting crevices partly filled with soil, or colonising bare soil between a closed association and a bare vertical rock face. On the west coast it was found in similar habitats from the extreme north of Scurrival to the most southerly points visited, at the foot of B. Tangaval. While not found at all on high ground in the east or central hills, it ascended for several hundred feet on all western hill slopes examined.

**Camptothecium sericeum* Kindb. Confined to boulders near sea-level, but widespread and locally plentiful, especially on west coast.

C. lutescens B. et S. The dominant moss of partially fixed sand dunes at Vaslain, Allasdale, and Eoligarry, but somewhat local; often growing with *Ditrichum flexicaule* and other mosses, and occupying a different zone from *Tortula ruraliformis*.

**Brachythecium albicans* B. et S. Taken occasionally among other mosses on sand.

B. rutabulum B. et S. Not abundant but widely distributed on banks, usually occurring in small quantities among other mosses; grew on trees in Northbay plantation.

B. rivulare B. et S. Taken once on shady bank, Northbay.

**B. populeum* B. et S. Recorded on trees in Northbay plantation.

**B. plumosum* B. et S. Locally plentiful at low altitudes, being especially conspicuous on rocks about L. St. Clair and in Northbay plantation.

B. purum Dixon. Among the common mosses of the island, growing on sand, peat, or rock ledges, but tending to escape notice owing to its habit of growing always among grasses or other close vegetation.

Hyocomium flagellare B. et S. Not uncommon at various altitudes, but always demanding shade and moisture; prolific growth found among shaded boulders in Northbay plantation and on wet ledges on north slope of B. Tangaval.

Eurhynchium piliferum B. et S. Recorded on three occasions, on wet ledges at Northbay and on B. Tangaval, and on sand at Eoligarry.

E. praelongum Hobk. A common species, but restricted to low levels and shady situations.

E. myosuroides Schp. In shade of Northbay plantation, formed luxuriant growth on rocks and to a lesser extent on the bases of trees. Elsewhere grew in close cushions on boulders, displaying looser growth-form only in shade. Not uncommon, and ascending to the summits of the hills.

var. *brachythecioides* Dixon. A few records from damp rocks.

E. myurum Dixon. Found in abundance in shade of Northbay plantation on boulders; elsewhere taken only once, on an exposed rock at Vaslain.

E. striatum B. et S. Not uncommon on moist banks at low altitudes. Grew typically in Northbay plantation and elsewhere, while depauperated specimens were found on wet maritime sand at Allasdale; also recorded on sand-dunes at Eoligarry.

**E. rusciforme* Milde. Taken on three occasions, always associated with running water.

**Plagiothecium elegans* Sull. Taken twice on shady banks, at Northbay and Vaslain.

**P. pulchellum* B. et S. One record, on rocks at summit of B. Mhartuin.

P. denticulatum B. et S. Found only at Northbay, in plantation and on shaded banks.

P. undulatum B. et S. Widespread among other mosses on wet moorland slopes; also recorded in Northbay plantation.

******Amblystegium filicinum* De Not. Widely distributed and fairly common. Grew in typical form in marsh at foot of B. Mhartuin and in sand-filled rock crevices at Eoligarry, where it was locally plentiful; occurred in stunted form on wet sand at Allasdale with *Ceratodon purpureus* and *Pottia Heimii*, and in attenuated form on boulders at Northbay.

**Hypnum riparium* L. Taken once on wet ground at margin of L. an Duin.

H. stellatum Schreb. Plentiful in wet places, occurring locally on high ground, and more commonly at lower levels. Grew submerged in peat pools; stunted forms appeared on maritime sand.

H. exannulatum Gumb. One record, on marshy ground at Northbay.

H. revolvens Swartz. Occurring widely on marshy ground but never abundant; extending to wet maritime sand at Eoligarry. An unusual attenuated *forma* was taken in a peat pool near L. nic Ruaidhe.

**H. commutatum* Hedw. Taken only in wet shaded rock crevice, on north slope of B. Tangaval.

**H. falcatum* Brid. Locally plentiful on wet ground in north and west, but found only at low altitudes.

var. **gracilescens* Schp. Taken once, with *H. commutatum*, on wet shady crevice on B. Tangaval.

H. cupressiforme L. Probably the most widely distributed and generally common moss on the island. Plentiful on boulders and trees in Northbay plantation; elsewhere occurring on rock, humus, peat, and sand, but seldom luxuriantly and usually in mixture with other mosses.

var. *resupinatum* Schp. Recorded on rocks near Allasdale and in Breivig plantation.

var. **filiforme* Brid. Taken on trees in Northbay plantation.

var. *ericetorum* B. et S. Recorded on rocks near summit of Hartaval.

var. **tectorum* Brid. Recorded on banks at Northbay.

H. callichroum Brid. Taken among rocks on Hartaval.

H. molluscum Hedw. Fairly plentiful on wet banks and ledges at all altitudes; also taken on sand at Vaslain.

**H. palustre* Huds. One record, wet ledges on slopes of B. Tangaval.

H. scorpioides L. Not rare but somewhat local, being confined to very wet situations on peat, the long branches frequently spreading over adjacent wet rock surfaces; sometimes occurred submerged in peat pools.

H. sarmentosum Wahl. Found occasionally on very wet ledges in the hills.

H. cuspidatum L. Very common and generally distributed in all types of damp habitat ; the only moss found amid dense growths of flowering plants in marshes at L. St. Clair and Allasdale; occurred exceptionally on rocks and maritime sand.

H. Schreberi Willd. Commonly found with *H. cupressiforme*, *Brachythecium purum*, and others growing among flowering plants on moorland banks and ledges.

Hylocomium splendens B. et S. Locally very plentiful and generally distributed in similar situations to the last species.

H. loreum B. et S. Found not uncommonly in close association with other mosses on moorland banks.

H. squarrosum B. et S. Common and often plentiful on moorland banks, generally associated with *Hypnum Schreberi* and others. Also occurred on marshy ground and sand-dunes.

H. triquetrum B. et S. Locally common on sand-dunes; also recorded on moorland ledges on the west coast.

Summary.

The foregoing account embodies the results of recent visits to Barra, Outer Hebrides, to study the moss flora.

A table is given summarising the principal moss communities on the island, a tentative classification of habitats being submitted and its application considered. The nature of the substratum is used as a basis for the habitat classification, which is followed by a brief ecological discussion.

A systematic list of mosses is presented, and notes concerning distributions are appended as far as possible. The list comprises 153 species. Many of these are new vice-county records. The distribution on Barra of *Myurium Hebridarum* is considered in detail and is found to be predominantly western.

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A Rot of Scilla Bulbs caused by Penicillium cyclopium Westling. By Christina S. Macfarlane, B.Sc.

(Read 15th June 1939.)

In January 1938 a small consignment of bulbs of *Scilla campanulata* var. *albida* was delivered in St. Andrews from Holland. About a quarter of them was attacked and rotted by a fungus which proved, on examination, to be a species of *Penicillium*. Many bulbs bore large pustules of the green spores. The amount of rot varied, but some bulbs were so badly infected that growth was out of the question.

Thom (1930) mentions several species of *Penicillium* known to attack bulbs. These include *P. gladioli*, *P. corymbiferum*, *P. expansum*, *P. hirsutum* and *P. cyclopium*. The last four belong to a complex of related types. Their determination appears to be largely a matter of individual preference. Ainsworth (1937) notes the same species associated with rots of stored plants in Britain, with the exception of *P. hirsutum* and *P. cyclopium*. He does not mention any rot of *Scilla* due to this type of mould.

The Causal Fungus.

(*a*) Isolation.—Isolations were made on malt agar slopes from eight of the more seriously infected bulbs. The following inocula were used: externally and internally borne spores, visibly rotted tissue, expressed juice from rotted cells and apparently sound tissues from just beyond the limit of visible infection. All, except the last which gave no growth, yielded cultures of the same *Penicillium*.

(*b*) Identification in Culture.—With a view to its identification the characters of the fungus were studied on the following media: 2 per cent. malt agar, prune gelatine [Thom (1930)], gelatine, [Muir and Ritchie (1927)], Barnes's Medium M [Gwynne Vaughan and Barnes (1937)], Czapek's Solution [Chamberlain (1905)], potato blocks and wheat grains. Measurements of spores, etc., were made *in situ* from growth on thin films of malt agar on microscope slides, following Sass's (1929) method. These films were stained

with an erythrosin-glycerine medium which did not swell the mycelium to any marked extent.

The features on malt agar were: colonies with dark centres surrounded by an area of delicate, white or colourless hyphae, mainly submerged in the substratum; diameter of hyphae 2·5–3·2 μ, average 2·8 μ. Colonies blue-green in colour, darkening with age to true green [Séguy (1936), nos. 309, 307, and finally 306]. Reverse pale yellow at first, shading to deep brown [nos. 339, 336, and finally 701]. Obvious zonation particularly in older cultures. Margin of colony level; consisting of submerged hyphae. There was an inner ring of white, ascending hyphae and, in the centre, aerial, conidia-bearing hyphae. The conidial area exuded drops of pale yellow liquid. The conidiophores were mainly smooth but some showed a faint wartiness. The cultures appeared almost velvety. There were only slight indications of fasciculation in young, strongly growing colonies. Neither perithecia nor sclerotia were formed. Cultures had a pronounced earthy odour.

On prune gelatine the growth was markedly fasciculate. The warty character of the conidiophores was much more obvious. The young growth showed a transient blue colour [no. 449].

The fungus was grown on the other media mentioned largely in an effort to induce perithecium formation. These attempts were not successful. So far only one fasciculate species of *Penicillium* has been shown to produce the perfect stage. Some of the more interesting features observed on these media were (1) in gelatine stab cultures the medium was liquified to a depth of 3·5 cm. in five weeks; (2) on Czapek's solution in conical flasks the surface growth buckled to a marked degree; (3) on plates of Barnes's Medium M the buckling took the form of radiating ridges suggesting the spokes of a wheel.

Microscopic features of the mycelium were studied by films, by the split disc method [Chamberlain (1905)] and by pieces of mycelium from all media. There were few noteworthy characters. In old cultures on prune gelatine hyphae were found which showed intercalary oidia. On films of malt agar and Barnes's Medium M swelling of the hyphal tips prior to branch formation was readily seen. It is worth noting that

the sparser growth produced on the latter medium makes it easier to observe individual hyphae accurately. Crystals surrounding the hyphae were often present. These were shown to be calcium oxalate by their solubility in dilute hydrochloric acid and their insolubility in acetic acid. Measurements made on films were as follows:—

Conidiophores, diameter 3·1–5·1 μ, average 3·5 μ; length 125–680 μ, average 469 μ.

Penicillus asymmetrical, 50–124 μ, average 81 μ.

Metulae length 9·8–13·1 μ, average 11·6 μ.

Sterigmata length 8·1–9·6 μ, average 8·6 μ.

Conidia round, borne in compact chains, 2·9–4·1 μ, average 3·46 μ.

Using Thom's (1930) classification of the *Penicillia* this fungus comes into the group Fasciculata in the division Asymetrica. The bulk of the evidence cited points to it being *Penicillium cyclopium* Westling. Prune gelatine was the medium on which Westling (1911) first investigated and diagnosed the species. The spore measurements do not agree very well with Westling's figures of 2·6–3·2 μ. The earthy odour too has not been observed in most cultures of Westling's fungus. However, Thom (1930) mentions a culture, which he received from Biourge and confirmed as *P. cyclopium*, in which there was this noticeable and characteristic rooty smell.

The identity of the fungus in the present instance was confirmed at the Centraalbureau voor Schimmelcultures, Baarn.

(*c*) Effect on Scilla bulbs.—Infected bulbs may be completely rotted, the growing point damaged, or the injury may be confined to the basal region of a number of leaves. Infection and rotting may both take place in storage. The fungus is spread by the externally borne conidia and by contact between adjacent bulbs.

The brown, infected areas are clearly marked off from the healthy tissue.

Microtome and hand sections of portions of attacked bulbs were stained with erythrosin or light green in clove oil, or with cotton blue in lactic acid. Material was also examined by Chesters' (1934) cotton blue block method. Results in every case confirmed that the fungal hyphae were confined

to the visibly rotted tissues. There was hypertrophy of the tissues. Infected cells usually contained a dense mass of hyphae. Individual hyphae penetrated the cell walls without undergoing any alteration in size.

Infection Experiments.

Bulbs of *Scilla campanulata* and *Sc. nutans* were sterilised with 0·5 per cent. mercuric chloride, thoroughly washed with sterile water and treated with spores of the fungus. The effect of wounding, moisture and temperature was investigated. The details are given in the following table.

No. of Exp. and type of bulb.	Treatment.	Temperature.	Results.
A.1. 2*S. camp.* and 2*S. nutans.*	Kept dry; outer skin intact; dusted with spores.	± 16° C.	No infection.
A.2. 2*S. camp.* and 2*S. nutans.*	Kept dry: outer skin wounded; dusted over the wound with spores.	± 16° C.	No infection on 3; short-lived mycelium on one *S. nutans.*
B.1. 2*S. camp.* and 2*S. nutans.*	Kept moist; outer skin intact; dusted with spores.	± 16° C.	No infection.
B.2. 2*S. camp.* and 2*S. nutans.*	Kept moist; outer skin wounded; the wound infected.	± 16° C.	In 3 days faint traces of growth on all; in 5 days this was definite; spores seen on 7th day.
C.1. 2*S. camp.* and 2*S. nutans.*	Kept moist and warm: outer skin intact; dusted with spores.	± 20° C.	No infection.
C.2. 2*S. camp.* and 2*S. nutans.*	Kept moist and warm; outer skin wounded; wound infected.	± 20° C.	In 3 days infection on all; spores seen on 5th day; later amber drops on one infection.

The fungus present in the induced rot was isolated. In culture it proved to be identical with the original isolates from naturally infected bulbs.

The results show that infection was dependent on the fungus gaining entry through a wound. In the absence of external moisture there was only one case of infection. The growth in this instance was short-lived. It is therefore clear that a supply of moisture is necessary for the fungus to establish itself permanently. On comparing the results obtained when wounded bulbs were cultured in a moist atmosphere at $\pm 16°$ C. and $\pm 20°$ C. it is seen that the higher temperature increased the growth rate of the mycelium.

Conclusion.

The addition of *Scilla campanulata* and *Sc. nutans* to the list of hosts attacked by *Penicillium cyclopium* Westling is by no means unexpected. Westling (1911) first isolated it from rotten fruit; but Thom (1930) reports its incidence on fruit and tulip bulbs. On the latter host it caused a rot similar to that on Scilla. Thom also refers to the fact that he obtained from Miss Pratt, who was working with "hyacinths," two forms, one of which "shaded from this sp. (*P. hirsutum*) towards *P. cyclopium* Westling."

The infection experiments undertaken proved that carefully controlled storage conditions would check the spread of this fungus. Injury is necessary before the fungus can gain entry. Moisture, high temperature, and contact between bulbs are all predisposing factors for attack. As bulb stocks in most cases are relatively small this should simplify the problem of selecting and packing only sound bulbs for future sale.

Summary.

1. A blue-green mould causing a storage rot of *Scilla campanulata* bulbs was isolated.

2. Culture characters proved it to be *Penicillium cyclopium* Westling.

3. Numerous attempts made to induce the formation of perithecia were unsuccessful.

4. The effect of the parasite on the host was studied.

5. Infection experiments undertaken with *Scilla campanu-*

lata and *Sc. nutans* showed that injury and an external source of moisture are necessary for infection. High temperature and contact between bulbs favour the spread of the fungus.

This work was carried out in the Botany Department of the University of St. Andrews. The writer wishes to express her thanks for the supervision received.

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A Study of the Pericycle in the Caprifoliaceae.

By Thomas B. Cooper, B.Sc.

(Read 15th June 1939.)

The aim of this work was to examine the distribution, structure, and development of the pericyclic fibres occurring in the Caprifoliaceae. These fibres are briefly referred to in Solereder (3) but no detail is given.

The family Caprifoliaceae contains eleven genera, namely: *Sambucus*, *Viburnum*, *Triosteum*, *Symphoricarpos*, *Abelia*, *Dipelta*, *Linnaea*, *Alseuosmia*, *Lonicera*, *Diervilla*, and *Leycesteria*. Of these the following genera were examined: *Sambucus*, *Viburnum*, *Symphoricarpos*, *Lonicera*, *Diervilla*, *Leycesteria*, *Abelia*, and *Linnaea*. The bulk of the material was cut in October, but in the following spring apices and young stems were obtained from *Lonicera sempervirens*, *L. nitida*, *Sambucus*, and *Viburnum*.

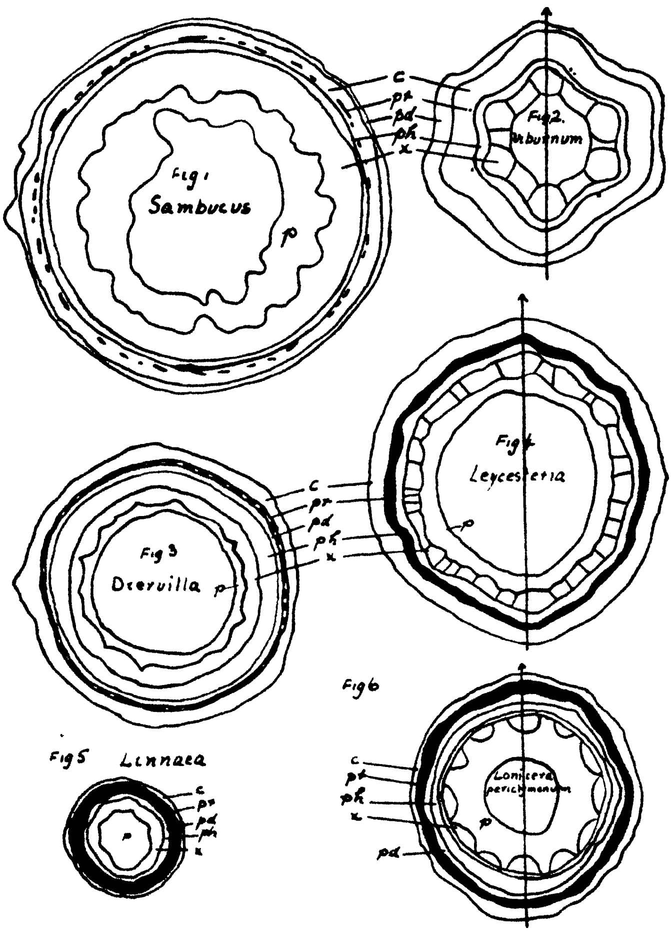
General Topography of Stem.

The phyllotaxis is opposite and decussate, and the stem varies in outline from circular to hexagonal, depending upon the size and persistence of the leaf bases (figs. 1–6). In the majority of cases the leaf trace is triple and the median leaf trace bundle is larger than the others. The stele is entirely composed of foliar bundles, and in the internode two axes of symmetry can be seen, the principal joining the median leaf traces of the nearest node and the other at right angles to this.

The nodal anatomy has not been fully investigated, but it is obvious from the varying number of bundles in the primary stem (*Viburnum*, *Lonicera sempervirens* and *L. periclymenum* 12, *L.* sp. 18, *Abelia* 14) that the leaf traces persist for varying distances in the different genera. The vascular bundles are separated by distinct rays so that the primary stele is dissected. In the young stem the greatest area is occupied by the pith, the cortex being about the same width as the vascular ring.

Histology.

Cuticle and Epidermis.—The cuticle is unusually thick in *Leycesteria* and *Viburnum.* The epidermal cells are square, rectangular, or rounded. Stomata are very obvious in



Figs. 1–6.—Regional drawings. Arrow shows main axis of symmetry. c = cortex; pr = pericycle; ph = phloem; pd = periderm; x = xylem; p = pith.

Leycesteria, but are much less frequent in the others. Scattered trichomes are present in *Abelia* and *Lonicera nitida.*

Cortex.—The cortex, five to eight layers, is composed mainly of parenchyma, but the outer two or three layers may consist

of collenchyma. In *Leycesteria* the cortex next to the epidermis is composed of palisade cells, and air spaces are found in the region of the stomata. *Diervilla* has a sub-epidermal layer of dark-coloured cells.

As a result of secondary growth, the outer cortical cells become crushed in many cases.

A starch sheath is present in the primary stem of *Abelia* (fig. 11) and *L. sempervirens*, also in *Sambucus*, but no endodermis occurs.

Stele.—The pericycle is always present, varying in pattern in the different genera; it is composed of strongly lignified sclerenchymatous fibres. Their distribution is as follows:—

I. Fibres occurring singly, very few and scattered, *Viburnum Opulus* (fig. 8).

II. Fibres occurring in distinct discontinuous groups round the stele, *Sambucus nigra* (fig. 7).

III. Fibres occurring singly in a uniseriate ring interrupted by unlignified cells . . . . . . *Diervilla* (fig. 9).

IV. Fibres occurring mainly in a uniseriate continuous ring but often 2 fibres wide . . . . . . *Leycesteria* (fig. 10). *Abelia* (fig. 11).

V. Fibres occurring as a continuous ring, having the appearance of a network in transverse section. Ring mainly 1 but sometimes 2 or 3 cells wide . . . . *Lonicera nitida*. *L. periclymenum* (fig. 12). *Lonicera* sp.

Ring mainly 2 or 3 cells wide . . *Symphoricarpos* (fig. 13). *Linnaea borealis* (fig. 14).

Ring often 4 or 5 cells wide . . *Lonicera sempervirens*.

The fibres vary much in length and within narrow limits in width. The ends of the fibres are tapering except in *Sambucus* and *Viburnum*. Simple pits occur on the tangential wall in *Viburnum*. Bordered pits occur on both radial and tangential walls in the other types except in *Sambucus*, where they are confined to the tangential wall.

Phloem.—In general the phloem cells are a quarter to half the size of the cortical cells. Occasionally a single fibre may occur in the phloem of *Sambucus*.

Cambium.—At the stages examined (*i.e.* mature stem) its outline corresponds to the shape of the stem in transverse section.

Xylem.—As has been mentioned above, the number of primary bundles or xylem segments in the internode varies. Although the primary bundles are as a result of secondary

growth soon embedded in a woody ring, they usually can be seen projecting into the pith so that their outline and number can be distinguished.

The structure of the xylem has been thoroughly presented by Solereder (3), so that it has not been studied in detail in this investigation.

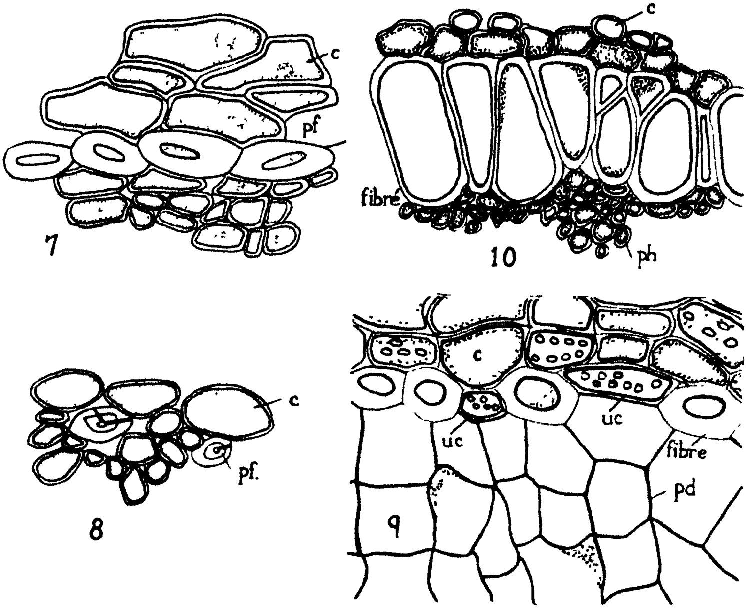


FIG. 7.—*Sambucus nigra*. FIG. 8.—*Viburnum Opulus*. FIG. 9.—*Diervilla*. FIG. 10.—*Leycesteria*. *c* = cortex; *pd* = periderm; *pf* = pericyclic fibres; *ph* = phloem, *uc* = unlignified cell (all × 200).

Rays.—The primary rays are usually wide (10–15 cells); they are obliterated in secondary growth, but the secondary wood is traversed by uniseriate lignified secondary rays.

Pith.—The pith is always large and composed of rounded hexagonal cells as seen in transverse section. Longitudinal section shows the pith cells to be isodiametric in *Diervilla*, *Sambucus*, and *Viburnum*, while in *Leycesteria* they are about twice as long as broad. Occasional stone cells are seen in the pith of *Sambucus*. The pith may be completely cellulosic and intact, as in *Diervilla* and *Linnaea*, or composed of a cellulosic central portion usually disrupted and surrounded by an outer pith of lignified cells varying in depth from four

to seven cells. In *Lonicera* the portions between the projecting primary bundles are lignified. The position of this extra mechanical tissue is such as to provide additional support against the pulling strains to which shrubs and particularly climbers are subjected.

Periderm.—Periderm formation is hypodermal in *Sambucus* and *Viburnum*. In the remaining types it is pericyclic, cork

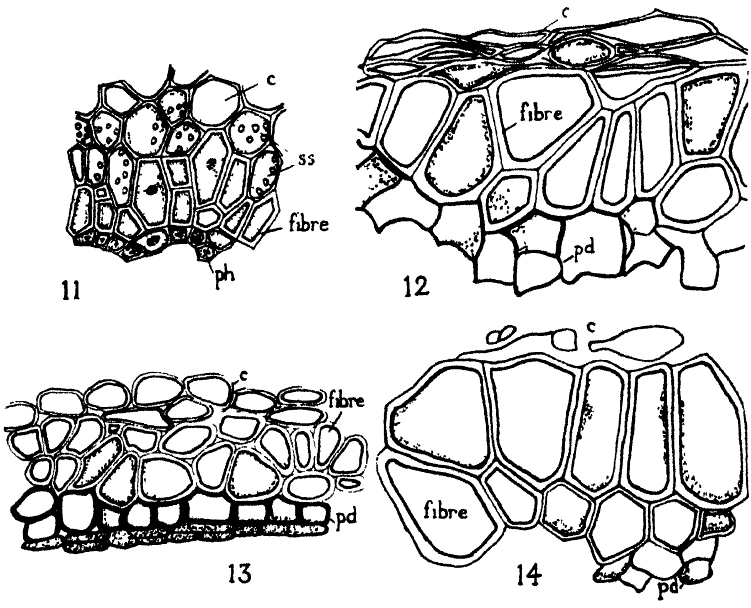


FIG. 11.—*Abelia*. FIG. 12.—*Lonicera periclymenum*. FIG. 13.—*Symphoricarpos*. FIG. 14.—*Linnaea borealis*. *c* = cortex (crushed in figs. 12 and 14); *pd* = periderm; *ph* = phloem; *ss* = starch sheath (all × 200).

formation taking place on the inner border of the pericycle, and in a one-year-old stem it is usually 3–4 layers in depth.

Differentiation of the Pericycle.—In those types in which the mature pericycle is composed of a complete ring of fibres, the first signs of differentiation of the pericycle are·to be seen immediately outside the median leaf trace segments of the nearest leaves.

At this stage the cells of the pericycle can be distinguished from those of the cortex by their more angular shape and by the beginning of vacuolation. The adjacent cortical cells are still rounded and scarcely vacuolated. Moreover, only one

or two protoxylem elements can be detected, and they are not yet lignified. It will be seen that the pericycle begins to differentiate, if not actually in advance of, at least simultaneously with the xylem. The distance from the tip of the stem at which differentiation begins is about ·07 mm.

On proceeding downwards to an older region of the stem, these areas of differentiating cells become united right round the stele, giving the pattern of the mature pericycle. Thus not only the general pattern of the mature pericycle, but also the shape and close-set position of the individual fibres is indicated from the start.

As the pericyclic cells differentiate further (distance approx. ·64 mm.), the protoplasm is seen to be completely vacuolated, appearing as a lining layer only.

After this (distance approx. ·84 mm.) the protoplasm begins to collapse, and can be seen as a more or less shrunken mass enclosing the nucleus. The whole cell is enlarging mainly in a radial direction, but the walls are still thin. The cells appear to be very easily distorted, re-entrant angles being often seen in the paraffin sections. That this collapse is not entirely due to fixation is shown by the fact that fresh material cut and examined in water showed the same effect.

In older sections (distance approx. 3·5 mm.) the pericyclic cells have apparently stretched again, because their walls are now straight, although not appreciably thicker. From this point further differentiation takes the form of thickening and lignification of the wall, and final disintegration of the protoplast. Since the fibres proceed to differentiate further after their apparent collapse, it is obvious that the protoplast must still be alive and functional.

It is probable that the collapsed stage in the differentiation of the fibres is the result of their greater susceptibility to plasmolysis owing to their vacuolated condition, the neighbouring parenchyma cells of the cortex being much less vacuolated and therefore more rigid.

Discussion.

The Caprifoliaceae contains 11 genera, mostly trees and shrubs with decussate, usually exstipulate leaves. They occur chiefly in the Northern Hemisphere and on mountains

in the tropics. Throughout the family the presence of pericyclic fibres is practically universal.

In the following table a comparison between habit and fibre development is given:—

Type.	No. of Species in Genus.	Habit.	No. of Fibres per Section (average).	Average Length.	Average Width.
				mm.	mm.
Sambucus	20	Tree	c. 400	1·5	
Viburnum	110	Tree	c. 3	1·13	
Symphoricarpos	8	Shrub	c. 300	7·99	·036
Abelia	11	Shrub	c. 250	6· 5	·028
Linnaea	1	Undershrub	c. 280	1·05	·041
Lonicera sempervirens	100	Climber	c. 750	9·14	·058
L. periclymenum		Climber	c. 350	5·43	·039
L. sp.		Shrub	c. 250	7· 9	·055
L. nitida		Shrub	c. 170	4·23	·038
Diervilla	8	Shrub	c. 150	c. 15	·023
Leycesteria	3	Shrub	c 220	9 92	·056

By far the greatest number of species in the family are shrubs, a few woody climbers occurring in the genus *Lonicera*, the only tree forms being *Sambucus* and *Viburnum*. It is generally considered that in the angiosperms the arboreal habit is primitive (1) and (2). On this ground *Sambucus* and *Viburnum* would appear to be the most primitive genera of the family. *Viburnum* shows the least development of the pericyclic fibres, both in number and in individual size. In *Sambucus* also the fibres are very short but occur in greater numbers.

Very long fibres occur in all the shrubs and woody climbers (except *Linnaea*). It is suggested that the fibres may serve the function of protecting the phloem against crushing in the young stem. The restricted northern distribution and dwarf growth form of *Linnaea* set it apart from the main line of progression of the family, and structurally speaking it may be interpreted as a reduced type.

An exact correlation of anatomical structure with growth form, habitat, and distribution would only be possible after a more exhaustive study of the species within the genera examined, but enough evidence has been secured to suggest strongly that such a correlation exists.

Summary and Conclusions.

1. The presence of pericyclic fibres has been recorded in all the types studied, and their disposition, size, and structure described.

2. A general account of the stem topography and anatomy is given.

3. Descriptions and diagrams of the differentiation of the pericycle have been included.

4. An attempt is made to correlate the number and length of the fibres with the habit in each group.

From the results we may conclude that it is possible to correlate the number and length of the fibres with growth form. In the arboreal forms a considerable amount of wood is made which provides the mechanical support and the fibres are small. The shrubs and climbers are characterised by rapid growth of stems, scanty formation of wood, and large piths. In such types the stereome is well developed and the individual fibres are long.

Linnaea with its dwarf habit and small fibres is regarded as a reduced form.

In conclusion my thanks are due to the staff of the Botanical Department, University College, Dundee, for their helpful co-operation and for material placed at my disposal.

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(2) ——. Significance of the "Foliar Ray" in the Evolution of Herbaceous Angiosperms. Annals of Botany, xxxvi (1922), 523–533.

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Plant Diseases of St. Andrews District. By J. A. Macdonald, B.Sc., Ph.D.

(Read 15th June 1939.)

In this note a list is given of plant diseases new to the St. Andrews area, which have been found in the last four years.

(1) Rust Fungi.—These have been collected extensively. A survey has been made of an area round St. Andrews corresponding with the following districts used by Young (1936):—

(*a*) The coastal half of district 2, and (*b*) the part of district 3 north of Fife Ness. In the present note only those rusts are mentioned which either are new records for the Tay area [Wilson (1934)] or have not been recorded for Scotland on the host or hosts cited. Where the record is preceded by a number this corresponds with that assigned to the rust in Wilson's (1934) list of the Distribution of the Uredineae in Scotland.

(*a*) New Records.—As far as can be ascertained there are no records of the following rusts from the district "Tay":—

7. *Uromyces Loti* : Uredospores and teleutospores of this rust have been found at the dunes and Kinkell Braes, on *Lotus corniculatus*.

94. *Puccinia Pruni-spinosae:* Uredospores and teleutospores were found abundantly in St. Andrews on cultivated plums and less freely on a tree which appeared to be a garden escape. This seems to be the first Scottish record of these stages. The aecidial stage, which occurs on *Anemone*, has not been observed.

99. *P. Pazschkei:* Teleutospores of this rust were discovered early in July 1939 on six plants of *Saxifraga Cotyledon* var. *Caterhamensis*. These plants had been purchased from Dorset in November 1937. Other species of *Saxifraga* growing in the same garden are not infected. This is also a new Scottish host record.

107. *P. Silenes:* Uredospores of this fungus were collected on *Lychnis diurna* at the dunes.

142. *P. Winteriana:* Characteristic circinate clusters of aecidia were found by Dr. M. E. Campbell on the leaves of *Allium ursinum* in Dura den.

209. *Melampsorella Symphyti:* This rust occurs in the Botanic Garden, St. Andrews, on *Symphytum officinale.* Only uredospores have been collected.

Puccinia Antirrhini: This fungus is well established on cultivated Antirrhinums. It was noticed first in 1936. Uredospores only have been found.

Uromyces Scirpi: This rust is not included in Wilson's list. It is described in Grove's British Rust Fungi (1914) and further information with regard to its distribution in England is given by Grove and Chesters (1934). Uredo- and teleuto-spores occur on *Scirpus maritimus,* while aecidia have been recorded on *Glaux maritima* and *Oenanthe crocata* among other plants.

All stages have been found at the Eden estuary. Spermogonia and aecidia are abundant on *Oenanthe crocata* and the other stages on *Scirpus maritimus.* The two hosts are growing intermixed in some parts. No aecidia have yet been found on *Glaux maritima,* which is also plentiful.

Work on the problems connected with this rust is being carried out by Miss Fort in the Botany Department at St. Andrews.

Uromyces striatus: Uredospores have been found on *Medicago lupulina* at Clatto Hill and near the Kinness burn, St. Andrews. Grove and Chesters (1934) include this fungus while noting its earlier inclusion by error in Grove's British Rust Fungi. It is not in Wilson's list of Scottish rusts.

(*b*) There does not seem to be any Scottish record of the following rusts on the host plants mentioned:—

55. *Puccinia Hieracii:* Uredospores and teleutospores were found abundantly on plants of *Hieracium murorum* var. *nigrescens* near the top of Ben-y-Vrackie. Of course this is outside the St. Andrews district, but it comes within the "Tay" area.

67. *P. Menthae:* All stages occur on *Mentha sativa.*

84. *P. Chaerophylli:* This was found on the casual *Chaerophyllum aureum* near St. Andrews castle. Unfortunately most of the ground on which the plants were established fell into the sea last winter. It is still uncertain if the fungus has survived on this host.

90. *P. depauperans:* All stages on *Viola cornuta* in cultivation.

93. *P. Malvacearum:* on *Malva rotundifolia*, *Lavatera arborea* and *Sidalcea* sp.

161. *Phragmidium violaceum:* The well-marked form of the bramble *Rubus fruticosus* var. *laciniatus* was found heavily infected in a St. Andrews garden. Possibly this may be a not uncommon occurrence, but it is unique in the writer's experience.

183. *Coleosporium Campanulae:* This has been found on *Campanula glomerata* and *C. persicifolia* in cultivation, but not on *C. rotundifolia*.

202. *Melampsora Euphorbiae:* on *Euphorbia Peplus*.

(2) Other Diseases.—Arum Leaf Blotch: *Phyllosticta richardiae* Brooks (1932). In the St. Andrews outbreak this fungus attacked Arum Lilies in three houses [Macdonald (1936)]. In one the yield of blooms was reduced to ⅛th of the normal figure of 30 per week. Dark water-logged areas appeared on petioles and leaves and, in extreme cases, all the leaf stalks became infected.

Artificial infection of young *Richardia* plants was carried out by atomising these with a spore suspension in water and keeping the plants moist under a bell jar for 7 days. The *Phyllosticta* was re-isolated from spores produced by pycnidia which formed on the tissues of petiole and leaf.

By following the controls recommended by Brooks the disease has been reduced to insignificant proportions in subsequent years.

Arum Spotted Wilt: *Lycopersicum Virus* 3. Brittlebank [Smith (1937)]. This disease, which was described by Ainsworth (1935), also appeared on *Richardia* in a single greenhouse during 1936. Vigorous roguing eliminated the trouble.

Powdery Mildew on *Cineraria:* The fungus responsible for the mildew of *Cineraria* is sometimes regarded as identical with that occurring on *Chrysanthemum*. In both cases the parasite is known only in the imperfect (*Oidium*) condition. The relationships are discussed by Sorauer (1932).

In spite of the fact that they are always grown in the same house with infected Chrysanthemums, Cinerarias were attacked for the first time by a powdery mildew late in 1938.

The occurrence has been commented on elsewhere [Macdonald (1939)] and the view expressed that in this instance the infection must have been seed borne.

Measurements were made of spores from *Cineraria* leaves and from the leaves of *Chrysanthemum* in the same house. The figures obtained were: *Cineraria* 23–35 × 13–21 μ, average 30·8 × 17·1 μ. *Chrysanthemum* 33–61 × 15–23 μ, average 40·8 × 19·2 μ. Spores in each case were mounted in 1 part cotton blue (c.b. 1 gm., dist. water 175 c.c.) in three parts lactic acid. The figures obtained for *Chrysanthemum* do not agree very closely with those given by Saccardo (1886) [40-50 × 20–25 μ] though they more than cover the length range. Nevertheless on the basis of these figures the spore size difference between the two hosts indicates that the *Oidim* on *Cineraria* and that on *Chrysanthemum* are indeed different.

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THE SCOTTISH ALPINE BOTANICAL CLUB EXCURSION, 1938. By ROBERT MOYES ADAM, F.L.S. (With Pls. XLIV–XLVI.)

(Read 19th October 1939.)

Few parts of Scotland can be said to have a greater fascination for both the naturalist and the ordinary tourist than the Misty Isle of Skye. The Cuillin range, unique among Scottish mountains, is of igneous origin and its rocks occur as masses of gabbro and basalt with intrusive volcanic material which, in the form of dykes, intersects the range at many points. Toughness and hardness are the features of the rocks, and this accounts for an almost complete absence of weathered soil. Denudation by the action of frost and the work of glacier ice have carved the hills to a marked degree. The summits are characterised by a spectacular array of splintered ridges and crests, the spires and pinnacles of which make up the attractive outline associated with views of the island. The corries are singularly wild and impressive, with slopes of sensational steepness littered with a confusion of torn fragments from surrounding cliffs.

The chief botanical interest of the Island, which the Club visited for the first time in 1938, was the presence of *Arabis alpina* and *Eriocaulon septangulare*. The former plant was first discovered in the Cuillins by the Irish botanist H. C. Hart in 1884, and no other British habitat is known. The latter, whose chief home is in eastern North America, was discovered in Skye in 1768 by a student of Dr. John Hope, then Professor of Botany in Edinburgh University. Since then it has been found in County Kerry, Ireland, and in the Island of Coll, and quite recently in the Island of Scalpay, near Portree; but no other European station is known.

The headquarters of the Club were fixed at Portree, and on 23rd July the members set out for Coir' a Mhadaidh to find *Arabis alpina*. The journey to Sligachan was made by car, thence the party proceeded on foot by the old drove road over Bealach' a Mhaim towards Glen Brittle. This gave a chance to see something of the vast area of moorland

Arabis alpina with *Chrysosplenium* and *Alchemilla* upon a rock ledge in Coir' a Mhadaidh.

Robert Moyes Adam.

that extends over the base of the Cuillins. Peat soils dominate and grasses such as *Molinia* and *Nardus* are everywhere in evidence. For part of the way the path lies by the Allt Dearg Mor or Red Burn, where *Calluna* is plentiful and stunted Holly, Rowan, and Birch find shelter along its course. Patches of gravel beside the stream supported some interesting plants, among which was *Alchemilla alpina*.

At the summit of the pass the party left the path, crossed a series of peat hags and ascended an outlying spur of Bruach na Frithe. The soil on this slope was composed of fine rock material, and had a sprinkling of *Alchemilla alpina* and a few small plants of *Silene acaulis*. Above this level drier soil and more stones reduced the plant life, and finally a long slope was reached composed of angular debris of crumbling lava. From this elevation a comprehensive view was obtained of the great hollow Coire na Creiche.

Coir' a Mhadaidh, which forms the north-eastern division, could be seen shaped like an elevated recess surrounded by cloud-capped mountains. The approach necessitated the crossing of a wide scree whose equilibrium scarcely withstood the passage of the party. After this tiring experience firmer footing was gained and the threshold of the corry reached. Great black bastions of gabbro, smoothed and polished by ice, guarded the entrance. A tiny rivulet that could be heard but not seen isssued forth through a deep defile. Vertical walls of naked rock frowned down on rakes of loose stones, above which a notched skyline indicated the shattered ridge whose splinters lay scattered in a chaos at the bottom.

The search of the day commenced when an ascent was made up the longest of the stone shoots, which sloped steeply down from the forbidding side of Sgurr an Fheadain. The scarcity of plant life was remarkable, hardly a vestige of green relieved the barrenness of the stony slopes. After the toil to the top of the scree some plants, including Sea Campion and Parsley Ferns, were found struggling for an existence among firmly fixed boulders. Where the cliff and scree met, a fringe of grassy vegetation had a foothold, and further up on damp and wet slabs and in chinks of the gabbro were some large specimens of *Arabis petraea* and several mosses.

A long fissure that rent the cliff at a higher level was next investigated. This gully cut across the rock-face obliquely

and followed a line where some intrusive material had broken down and disappeared. The cleft was wet and was bordered by slabs which projected on either side. Occupying this space were pockets of pale-coloured clay soil on which quite a display of plant life flourished. Two patches of the desired *Arabis alpina* were observed, and beside them a group of *Chrysosplenium oppositifolium*. Few flower heads were seen on the *Arabis*, but the vigour of these plants indicated a strong vegetative habit.

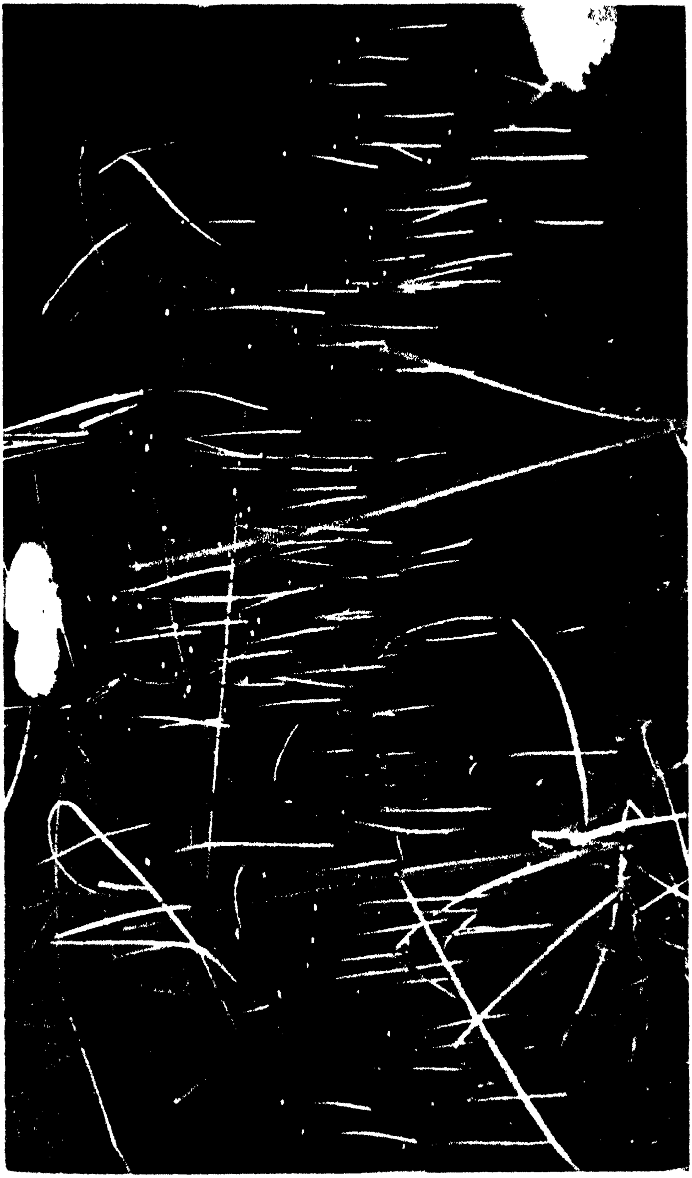
The elevation was about 2300 feet. After a thorough search of the gully the party descended, crossed the moorland which occupies the wide mouth of Coire na Creiche to the Glen Brittle path, and so by Sligachan to Portree.

The following plants were observed between Sligachan and Coir' a Mhadaidh: *Thalictrum alpinum* Linn., *Ranunculus Flammula* Linn. var. *radicans* Nolte, *Trollius europaeus* Linn., *Arabis alpina* Linn., *A. petraea* Lam., *Cochlearia alpina* Wats., *C. micacea* E. S. Marshall, *Viola canina* Linn., *Polygala vulgaris* Linn., *P. serpyllacea* Weihe, *Silene maritima* With., *S. acaulis* Linn., *Hypericum pulchrum* Linn., *Geranium Robertianum* Linn.,*Rubus saxatilis* Linn.,*Alchemilla alpestris* Schmidt, *A. alpina* Linn., *Rosa spinosissima* Linn., *Saxifraga stellaris* Linn., *Chrysosplenium oppositifolium* Linn., *Sedum roseum* Scop., *Drosera anglica* Huds., *Epilobium alsinefolium* Vill., *Galium boreale* Linn., *Solidago Virgaurea* Linn. var *cambrica* Huds., *Antennaria dioica* Gaertn., *Gentiana amarella* Linn., *Linaria Cymbalaria* Mill., and *Pinguicula lusitanica* Linn.

The following morning the party returned to Sligachan with the intention of finding *Eriocaulon septangulare*, and it was met with in Loch an Eilean, near Sligachan. This loch is one of several which lie among the moraines between Glen Sligachan and Glen Drynoch and which are the Caiplich Lochs where the plant was first seen, and indeed, is its only habitat in Skye.

Growing beside *Nymphaea*, *Menyanthes*, *Lobelia*, and *Carex* the *Eriocaulon* was found to be plentiful. All the plants were submerged and in dense clusters from which many flower heads rose above the surface of the water, with an anchorage to a bottom of mud and sand.

From Loch an Eilean the members drove down Glen Drynoch to Loch Harport. At the head of this sea-loch an



Eriocaulon septangulare. A group showing foliage and flower heads in Loch an Eilean, Sligachan.

Robert Moyes Adam.

interesting salt marsh was visited, as well as a tract of boggy moor where the River Drynoch enters the sea. After this a road journey was taken by way of the districts of Bracadale, Greshornish and Snizort, through wide undulating terraced moorlands with hills of strangely flattened tops—country built up from decayed lava-flows and sills. Agricultural land forms a belt along the shores with crofting communities, and in the shelter of some of the valleys as at Kerral and Skeabost plantations were seen of surprising luxuriance.

The following plants were observed beside Loch an Eilean and Loch Harport shore: *Nymphaea alba* Linn., *Spergularia marginata* Kittel, *S. rubra* Presl, *Parnassia palustris* Linn., *Drosera rotundifolia* Linn., *D. anglica* Huds., *Callitriche stagnalis* Scop., *C. intermedia* Hoffm., *Epilobium palustre* Linn., *Hydrocotyle vulgaris* Linn., *Chrysanthemum segetum* Linn., *C. Leucanthemum* Linn., *Senecio aquaticus* Hill, *Cnicus heterophyllus* Willd., *Lobelia Dortmanna* Linn., *Lysimachia nemorum* Linn., *Glaux maritima* Linn., *Menyanthes trifoliata* Linn., *Scrophularia nodosa* Linn., *Mimulus Langsdorfii* Donn, *Pedicularis palustris* Linn., *P. sylvatica* Linn., *Rhinanthus minor* Ehrh., *Plantago maritima* Linn., *Orchis elodes* Gris., *Platanthera chlorantha* Reich., *Leucorchis albida* Mey., *Gymnadenia conopsea* Br., *Iris Pseudacorus* Linn., *Juncus Gerardi* Lois., *Triglochin maritimum* Linn., *Potamogeton polygonifolius* Pourr., *P. perfoliatus* Linn., *Eriocaulon septangulare* With., *Scirpus fluitans* Linn., *Rhynchospora alba* Vahl, *Schoenus nigricans* Linn., *Carex echinata* Murr., *C. leporina* Linn., *C. panicea* Linn., *C. flava* Linn., *C. inflata* Huds. and *Glyceria maritima* Mest. et Koch.

The next day was spent in the north-western districts of the Island and commenced with a visit to the environs of Dunvegan, where some time was spent examining the shores of Loch Dunvegan. Part of Duirinish was then explored by Glendale and Loch Pooltiel to the sea cliffs at Ramasaig. Some of the coastal scenery of this district surpasses in grandeur any other of the Island's seaboard. The lava plateau out of which this part of Skye is formed ends in an abrupt series of vertical precipices which culminate in the magnificent Waterstein Head, which rises nearly 1000 feet above the sea. Streams cut their way through these rocky ramparts down ravines whose sides are richly clothed with

maritime plants. Along the verge of the cliffs the effect of wind is shown by the absence of turf, while inland lies a wide stretch of peaty grassland providing good grazing for sheep.

On the same day a visit to the shores at Trumpan yielded some fine specimens of *Orobanche rubra* parasitic on *Thymus Serpyllum*. They were found on an earthy bank of a "raised-beach."

Near Portree the following plants were found: *Stachys officinalis* Trev., *Oxyria digyna* Hill, *Juncus tenuis* Willd., *Luzula spicata* DC, *Triglochin palustre* Linn., *Carex flava* Linn., *Asplenium trichomanes* Linn., *Cystopteris fragilis* Bernh., and *Lycopodium Selago* Linn.

The final outing covered a wide area in the district of Trotternish. It began at Lochs Fada and Leathan, where there were some interesting aquatic plants. Then an ascent was made to The Storr—a mountain of ancient lavas, which have weathered to form stupendous buttresses and pinnacles. One named "The Old Man of Storr" is a huge monolith 160 feet in height. The plant life of the rocks was confined to damp ledges and crevices where it was abundant. On the slopes below a fine soil of rock debris yielded a rich and abundant pasture.

A similar geological formation was seen at the Quiraing, an amazing space set among towering cliffs, entrance to which is gained through a narrow gap. In olden times the place was used to hide stolen cattle.

At Staffin the coastal belt is fashioned from calcareous rocks and sediments upon which a rich and interesting flora has developed; and the same was found on the shores at Uig. The time available, however, was too brief for all but a passing acquaintance with the plant life of these areas. With the return to Portree that night the Club's outing came to an end.

Coire na Creiche showing Coir' a Mhadaidh and Sgurr an Fheadain, the habitat for *Arabis alpina* at the left side.

Robert Moyes Adam.

ROLL

OF

THE BOTANICAL SOCIETY OF EDINBURGH.

Corrected to 1st November 1939.

HONORARY FELLOWS.

BRITISH SUBJECTS (LIMITED TO TWELVE).

Date of Election	
April 1938.	BUTLER, Sir EDWIN JOHN, C.M.G., C.I.E., M.B., D.Sc., F.R.S., 34 *Glazbury Road, Baron's Court, London, W.* 14.
Dec. 1907.	FARMER, Sir JOHN BRETLAND, M.A., D.Sc., F.R.S., *St. Leonard's Weston Road, Bath.*
April 1938.	GUSSOW, HANS THEODOR, LL.D., F.R.S.C., *Dominion Botanist. Central Experimental Farm, Ottawa, Canada.*
April 1938.	HILL, Sir ARTHUR WILLIAM, K.C.M.G., M.A., Sc.D., F.R.S., *Director, Royal Botanic Gardens, Kew.*
Dec. 1930.	LANG, WILLIAM HENRY, M.B., C.M., D.Sc., F.R.S., *Barker Professor of Cryptogamic Botany, University of Manchester.*
April 1935.	LLOYD, FRANCIS ERNEST, M.A., D.Sc., *Emeritus Professor, Box* 842, *Carmel, California, U.S.A.*
April 1938.	POLE EVANS, ILLTYD BULLER, C.M.G., M.A., D.Sc., *Irene, Transvaal, South Africa.*
June 1923.	PRAEGER, ROBERT LLOYD, B.A., D.Sc., 19 *Fitzwilliam Square, Dublin.*
April 1938.	SALISBURY, EDWARD JAMES, C.B.E., D.Sc., F.R.S., *Quain Professor of Botany, University College, Gower Street, London, W.C.* 1.
April 1935.	SEWARD, Sir ALBERT CHARLES, M.A., Sc.D., F.R.S., 3 *Adams Road, Cambridge.*

FOREIGN (LIMITED TO TWENTY-FIVE).

June 1923.	CAMPBELL, Dr. DOUGLAS HOUGHTON, *Professor of Botany, Stanford University, California, U.S.A.,—Corresponding Member, Dec.* 1905.
Oct. 1935.	CLAUSEN, Dr. JENS, *Carnegie Institution of Washington, Division of Plant Biology, Stanford University, California, U.S.A.*
Mar. 1934.	DIELS, LUDWIG, Dr.Phil., F.L.S., *Professor of Botany and Director of the Botanic Garden and Museum, Berlin-Dahlem.*
Oct. 1935.	ELFVING, Dr. FREDRIK, *Professor Emeritus of Botany, Kopmansgatan* 10, *Helsingfors, Finland,—Corresponding Member, Mar.* 1895.
Mar. 1934.	HANDEL-MAZZETTI, Dr. HEINRICH, *Botanische Institut der Universität, Rennweg* 14, *Wien III.*
April 1938.	HU, H. H., D.Sc., *Professor of Botany, Fan Memorial Biological Institute, Pekin.*
April 1938.	HUMBERT, Professor H., *Museum of Natural History, Paris.*
June 1923.	IKENO, Professor SEITTSIRO, Ph.D., *Agricultural College, Imperial University, Tokyo, Japan.*

Date of Election.

June 1923. MacDougal, Dr. D. T., R.F D., 170 *Carmel, California.*

Oct. 1935. Miyabe, Dr. Kingo, *Emeritus Professor of Botany, Hokkaido Imperial University, Sapporo, Hokkaido, Japan;—Corresponding Member, Dec.* 1905.

June 1923. Osterhout, W. J. V., Ph.D., *Rockefeller Institute, 66th Street and Avenue A, New York, U.S.A.*

Mar. 1934. Rehder, Alfred, A. M., *Curator, Arnold Arboretum, Jamaica Plain, Mass., U.S.A.*

April 1938. Svedelius, Nils Eberhard, *Professor of Botany and Director of the Botanic Garden, Upsala, Sweden.*

June 1902. Trelease, Dr. William, *University of Illinois, Urbana, Illinois, U.S.A.*

Mar. 1934. Tubeuf, Carl Freiherr von, Professor Dr., *Habsburger Str.* 1, *Munich, Germany.*

Mar. 1934. Turesson, G. W., Fil.Dr., *The University, Lund, Sweden.*

Mar. 1934. Vavilov, Professor N. I., *Director of the State Institute for Experimental Agronomy, Ul. Gerzena, Leningrad, U.S.S.R.*

Oct. 1935. Westerdijk, Dr. Joh., *Professor of Phytopathology, Utrecht and Amsterdam, Javalaan,* 4, *Baarn, Holland.*

ORDINARY FELLOWS.

No distinguishing mark is placed before the name of Fellows who contribute annually and receive Publications.

* *Indicates Fellows who have compounded for Annual Contribution and receive Publications.*

† *Indicates Non-Resident Fellows who have compounded for Publications.*

‡ *Indicates Non-Resident Fellows who do not receive Publications.*

Date of Election.

Oct. 1936. Aberconway, Lord, C B E., *Bodnant, Tal-y-Cafn, N. Wales*

Dec. 1915. Adam, Robert Moyes, F.L.S., 17 *West Brighton Crescent, Portobello, Edinburgh*

Jan. 1934. Ainsworth, Sir T , Bart., *Ardanaiseig, Kilchrenan, Argyll.*

Nov. 1924 *Alcock, Mrs. N. L , M.B E., F.L S., 12 *Tavistock Square, London, W C* 1.

Oct. 1937. Allison, Arthur H. S., 19 *Salkeld Road, Penrith, Cumberland.*

Feb. 1925. Anderson, J. B., 76 *South Trinity Road, Edinburgh,* 5.

Nov. 1926. *Anthony, John, M.C., M A., B Sc., 120 *Trinity Road, Edinburgh,* 5.

Dec. 1924. Armstrong, D., *The Drum, Gilmerton, Midlothian.*

Dec. 1908. ‡Balfour, F. R S., M.A. 13 *Collingham Gardens, London, S W.* 5

Oct. 1935. Barr, Rev. Robt , M.A , J.P., *The Manse, Neilston, Renfrewshire.*

May 1891. *Berwick, Thomas, 56 *North Street, St. Andrews.*

Feb. 1919. †Blackburne, Cecil Ireland, *Weydown Hatch, Haslemere, Surrey.*

April 1926. Blackie, John Joseph, Ph D , A.I C., Ph.C., 104 *Holyrood Road, Edinburgh,* 8.

May 1888. *Bonnar, William, 51 *Braid Avenue, Edinburgh,* 10.

Dec. 1936. Boughey A S , B.Sc , A.R S , *Wad Medani, Sudan.*

Oct. 1935. Bowden, John, B.Sc , 55 *March Road, Blackhall, Edinburgh,* 4.

Dec. 1886. *Bower, F O., M.A , D.Sc., F.R.S., F.L.S., 2 *The Crescent, Ripon*

Mar. 1927. Boyd, Miss Lucy, D.Sc., 3 *West Brighton Crescent, Portobello, Edinburgh.*

Oct. 1935. Braid, Professor K. W., M.A., B.Sc , 6 *Blythswood Square, Glasgow.*

May 1924. †Brown, Miss Helen M., *Longformacus, Duns.*

Dec. 1906. †Bryce, George, D.Sc., *Dept. of Agriculture, Ibadan. Nigeria*

Dec. 1935. Bryson, Arch G., C.A., 20 *Inverleith Place, Edinburgh,* 4.

April 1926. Buchan, The Right Hon. the Earl of, *Almondell House, Mid-Calder.*

Nov. 1922. Buchanan, E. M., 76 *Warrender Park Road, Edinburgh,* 10.

Dec. 1921. ‡Burns, W., C.I.E., D.Sc., *Agricultural Expert, Imperial Council of Agricultural Research, New Delhi, India.*

Dec. 1924. †Burt, Miss C. C., B.Sc., 36 *Ravenshaugh Road, Levenhall, Musselburgh.*

Feb. 1938. Cadell, Miss Marion, *The Dean, Longniddry, East Lothian.*

Dec. 1938. Cadman, C. H., B.Sc., *Craig's House, Corstorphine, Edinburgh,* 12.

Oct. 1926. *Callender, Wm. C., *Georgefield,* 31 *Inverleith Terrace, Edinburgh.* 4.

Oct. 1925. Campbell, Mrs Agnes, 53 *Oxgangs Road. Edinburgh,* 10.

Oct. 1937. Campbell, Miss May Sherwood, *Layer Marney Hall, Kelvedon, Essex.*

Date of Election.

Jan. 1935. Chen, Feng-hwai, *Yunnan Botanical Institute, Kunming, Yunnan, China.*
Dec. 1928. Clarke, Robert R., B Sc., 18 *Biggar Road, Fairmilehead, Edinburgh,* 10.
Feb. 1933. Clouston, David, C.I.E., M.A., D.Sc., *Forthview, Boswall Road, Edinburgh,* 5.
Dec. 1936. Clouston, David, M.A., D.Sc., 41½ *Union Street, Aberdeen.*
April 1913. ‡Cooper, R. E., *Royal Botanic Garden, Edinburgh,* 4.
Nov. 1932. Corstorphine, R. H., *Hillside House, Arbroath.*
Mar. 1900. *Cowan, Alexander, M.A., *Valleyfield, Penicuik.*
Nov. 1933. Cowan, C. M., *St. Michaels, Musselburgh.*
Oct. 1930. Cowan, John M., M.A., D.Sc., 17 *Inverleith Place, Edinburgh,* 4.
Feb. 1923. †Cox, E. H. M., 6 *Hill Street, Broughty Ferry, Dundee*
Jan. 1922. *Dales, Mrs. H., M.A., B.Sc., *Allora, Kensington Gardens, Knock, Belfast.*
Oct. 1926. Davey, V. E. M., B.Sc., Ph.D., *Plant Breeding Station, Corstorphine, Edinburgh,* 12
Dec. 1903. Davidson, J. Randolph, M.A., B.Sc., 25 *Meadway Court, Golders Green, London, N.W.* 11.
Dec. 1911. ‡Davidson, John, F.L.S., *Associate Professor of Botany, University of British Columbia, Vancouver, Canada.*
Nov. 1925. De Pree, Mrs, *Beach Hill, Haddington.*
Dec. 1930. Dickson, Miss A M., *Woodhouse, Dunscore, Dumfriesshire.*
Nov. 1927. *Dobson, Miss Margaret Gairns, 8 *Polwarth Terrace, Edinburgh,* 11.
Nov. 1919. *Downie, Miss D. G, B.Sc., Ph.D., 1 *W. Stanhope Place, Edinburgh,* 12.
Oct. 1936. Dundas, Lt -Col. James C., D.S.O., *Ochtertyre, Stirling.*
Dec. 1937. Earnshaw, F., B.A, 13 *George Square, Edinburgh,* 8.
Feb. 1931. Egerton, Major-General Granville, 7 *Inverleith Place, Edinburgh,* 4.
Feb. 1917. †Eley, Charles, *East Bergholt Place, Suffolk*
Mar. 1932 Elphinstone, The Right Hon. Lady, *Carberry Tower, Musselburgh.*
Jan. 1883. *Evans, Arthur H, Sc.D, *Cheviot House, Crowthorne, Berks*
Dec. 1905. *Evans, W. Edgar, B Sc., F.R.S E., 38 *Morningside Park, Edinburgh,* 10
Jan. 1935. Fang, Wen Pei Ph D, *Department of Biology, College of Science, National Szechuan University, Chengtu, Szechuan, China.*
Dec. 1927. Fenton, E. Wyllie M.A., D.Sc., F.L.S, 16 *Hilton Road, Edinburgh,* 9.
Dec. 1933. Fleming, Mrs E. M., 10 *Chester Street, Edinburgh,* 3.
Oct. 1934. *Fleming, G J, 30 *Royal Circus, Edinburgh* 3.
Dec. 1934 Fletcher, H R., Ph.D., D Sc, *Royal Botanic Garden, Edinburgh,* 4.
Oct. 1928. Forster, Charles Edward, B.A., Ph D., *The Croft, 9 Hillview Terrace, Corstorphine, Edinburgh,* 12.
Dec. 1931. Forrest, Miss Grace, 11 *Rothesay Place, Edinburgh,* 3.
Oct. 1920. *Galloway, R. Angus, M C, B.Sc, 65 *Cluny Gardens, Edinburgh,* 10.
Dec. 1920. †Garnock, John, M.A, B.Sc., 35 *Craigmount Terrace, Corstorphine, Edinburgh,* 12
Feb. 1933. Gemmell, James W. S., M.A., B.Sc., 74 *Victoria Terrace, Dunfermline.*
May 1903. ‡Gilmore, Dr. Owen, L.R.C.P., L R.C.S E, 52 *Chelsea Square, London, S W.* 3.
Oct. 1936. *Gordon, H. D., B Sc, Ph.D., *Botany Dept, University of Tasmania, Hobart, Tasmania.*
Nov. 1921. *Graham, R. J. D., M.A., D.Sc., *Professor of Botany, The University, St Andrews*
Mar. 1923. Gray, John H., M.A. B.Sc., 28 *West Relugas Road, Edinburgh,* 9.
Jan. 1926. Gregor, James W., Ph.D., D.Sc, F.L.S, *North Clermiston House, Barnton, Midlothian.*
Mar. 1925. *Grieve, Miss Jean E., 11 *Lauder Road, Edinburgh,* 9.
Nov. 1932. Hales, Mrs. Jessie B., 48 *Craiglockhart Road, Edinburgh,* 11.
Nov. 1914. †Harley, Andrew, *Blinkbonny, Kirkcaldy.*
Dec. 1923. †Harris, Mrs. K., B.Sc., *Oakleigh, Elm Road, Early, Reading.*
April 1910. Harvey, Miss Elsie, *Kerala, Captain's Road, Liberton, Edinburgh,* 9.
Mar. 1913. †Hayward, Miss Ida M., F.L.S., 7 *Abbotsford Road, Galashiels.*
Dec. 1929. Heddle, R. G., M.A., B.Sc., 13 *George Square, Edinburgh,* 8.
May 1924. ‡Henderson, George, *Royal Academy, Inverness.*
April 1886. Hill, J. Rutherford, O.B.E., Ph.C., *St. Faiths, Balerno.*
Oct. 1926. †Home, Miss Logan, *Silverwells, Coldingham.*
Mar. 1920. Howison, Andrew, M.A., B.Sc., 18 *Beresford Avenue, Edinburgh,* 5.

Date of Election.	
Jan. 1935.	Jardine, Brig.-Gen. J. B., C.M.G., D.S.O., *Chesterknowes, by Selkirk.*
Oct. 1931.	Jeffers, R. H., N.D.H., F.C.S., F.L.S., 42 *Archery Road. Eltham, London, S.E.* 9.
Dec. 1907.	*Jeffrey, J. Frederick, *Laneside. Shipham. Winscombe, Somerset.*
Dec. 1935.	Johnson, J. W. H., C.A., 12 *Granby Road, Edinburgh*, 9.
Dec. 1912.	*Johnstone, James Todd, M.A., B.Sc., *Royal Botanic Garden, Edinburgh*, 4.
Jan. 1913.	*Kemp, Mrs. C. Norman, M.A., D.Sc., *Ivy Lodge, Laverockbank Road, Edinburgh*, 5.
Dec. 1938.	Kidd, Maurice G., B.L., W.S., 13 *Melville Street, Edinburgh*, 3.
Nov. 1924.	*King, Miss C. A., *Osborne Nursery, Corstorphine Road, Edinburgh*, 12.
Oct. 1921.	King, Miss Isabella M., B.Sc., 4 *Cambridge Gardens, Edinburgh*, 6.
Jan. 1932.	Knott, Eric, Ph.C., 72 *Craigleith Road, Edinburgh*, 4.
Jan. 1924.	*Knox, Mrs. J., M.A., B.Sc., 43 *Dalhousie Terrace, Edinburgh*, 10.
Nov. 1921.	*Laing, Ernest V., M.A., D.Sc., 13 *Belvedere Street, Aberdeen.*
Oct. 1935.	Lamb, Ivan M., B.Sc., *Dept. of Botany, British Museum (Natural History), Cromwell Road, London, S.W.* 7.
Dec. 1911.	*Lamont, Miss Augusta, M.A., B.Sc., *Inverchaolain, Toward, Argyllshire.*
Nov. 1927.	Lang, J. M. S., B.S.A., *Craig's House, Corstorphine, Edinburgh*, 12.
May 1931.	Latham, H. A., 27 *Organgs Road, Lothianburn. Edinburgh.*
Oct. 1935.	Lauder, Thomas, 12 *Adamswell Street, Glasgow, N.*
Dec. 1917.	Law, Mrs John, 41 *Heriot Row, Edinburgh*, 3.
Dec. 1922.	*Lewis, Herbert M. B.Sc., *Penucha, Caerwys, N. Wales.*
Oct. 1938.	Linton, Robert George, M.R.C.V.S., Ph.D., *Broomhill House, Lasswade, Midlothian.*
Dec. 1937.	MacArthur, Mrs Enid Clark, 30 *Warriston Avenue, Edinburgh*, 4.
Nov. 1922.	‡M'Call, David. B.Sc., Ph.D., *Dundee Technical College, Bell Street, Dundee.*
Oct. 1935.	M'Cutcheon, William, B.Sc., 89 *Argyle Road, Saltcoats.*
Feb. 1925.	Macdonald, James, B.Sc., *Forestry Commission, Llandaff Chambers, Regent Street, Cambridge.*
Feb. 1933.	Macdonald, James A., B.Sc., Ph.D., *Botany Dept., The University, St. Andrews*
May 1936.	*Macdonald, Miss Mary M., B.Sc., 11 *Eyre Crescent, Edinburgh*, 3.
Jan. 1895.	MacDougall, R. Stewart, M.A., D.Sc., LL.D., *Ivy Lodge, Gullane, East Lothian.*
Jan. 1881.	†Macfarlane, John M. Sc.D., LL.D., F.R.S.E., *Emeritus-Professor of Botany*, 427 *West Hansberry Street, Germantown, Pa., U.S.A.*
Dec. 1925.	*M'Intosh, A. E. S., B.Sc., Ph.D., *Assistant Geneticist, Dept. of Science and Agriculture, Barbados, B.W.I.*
Dec. 1934.	M'Rae, Wm., C.I.E., M.A., D.Sc., F.R.S.E., *Daramona, Gamekeeper's Road. Barnton, Midlothian*
Dec. 1896.	‡Mahalanobis, Professor S. C., B.Sc., F.R.S.E., P. 45 *New Park Street, Calcutta*
Nov. 1933.	Maitland, T. D., M.B.E., 20 *Craiglockhart Terrace, Edinburgh*, 11.
Dec. 1934.	Marindin, Mrs. *Fordel, Glenfarg, Perthshire.*
Feb. 1936.	Marindin, Miss Eve, *Fordel, Glenfarg, Perthshire.*
Oct. 1914.	*Martin, Miss Isa, M.A., 42 *Craigmount Gardens, Edinburgh*, 12.
April 1933.	Mather, Carroll J., Ph.C., B.S., 228 *South Gratiot Avenue, Mount Clement, Michigan, U.S.A.*
April 1933.	Mather, Enoch, M.S., M.D., 228 *South Gratiot Avenue, Mount Clement, Michigan, U.S.A.*
Mar. 1913.	*Matthews, James R., M.A., *Professor of Botany, The University, Old Aberdeen.*
Dec. 1916.	†Maxwell, Sir John Stirling, Bart., *Pollok, Pollokshaws, Glasgow.*
Oct. 1925.	Mercer, Miss Edith, 10 *Ventnor Terrace, Edinburgh*, 9.
April 1919.	‡Mills, A. E., 37 *High Street, Keynsham, near Bristol.*
Dec. 1923.	*Nelson, Alex., B.Sc., Ph.D., *Royal Botanic Garden, Edinburgh*, 4.
April 1916.	†Nicholson, C., F.E.S., "*Nansgwithick,*" *Tresillian, Truro, Cornwall.*
Dec. 1907.	*Orr, M. Y., F.R.S.E., *Royal Botanic Garden, Edinburgh*, 4.
Oct. 1914.	†Patton, Donald, M.A., B.Sc., Ph.D., 15 *Jordanhill Drive, Glasgow, W.* 3.
Nov. 1919.	Pealling, Robert J., M.A., B.Sc., *The Royal Academy, Inverness.*
Dec. 1917.	*Pike, J. Lyford, B.Sc., *Rosetta*, 56 *Kirkbrae, Liberton, Edinburgh*, 9.
Jan. 1915.	*Pinkerton, A. A., *Adele Cottage, Loanhead.*

Date of Election.

Oct. 1937.	Pollock, Sir J. Donald, Bart., O.B.E., LL.D., M.D., *Manor House, Boswall Road, Edinburgh*, 5.
June 1891.	†Prain, Sir David, M.D., C.I.E., F.R.S.S.L. & E., F.L.S., *The Well Farm, Whyteleafe, Surrey.*
Dec. 1932.	Redman, Miss A. W. H., B.Sc., 30 *Lomond Road, Edinburgh*, 5.
April 1877.	‡Riddell, Wm. R., B.A., B.Sc. (Hon. Mr. Justice), *Osgoode Hall, Toronto, Canada.*
Feb. 1926.	Robb, William, N.D.A., *Craig's House, Corstorphine, Edinburgh*, 12.
Mar. 1925.	†Rothschild, Lionel N. de, *Exbury, near Southampton.*
Feb. 1938.	Russell, David, LL.D , *Rothes, Markinch.*
Dec. 1889.	‡Russell-Murray, J., 241 *Clark Avenue, Westmount, Montreal, Canada.*
Oct. 1937.	*Sandeman, Mrs A. Stewart, *The Laws, Kingennie, Angus.*
Mar. 1935.	Sandilands, James, F.I.C., 102 *Westholmes Gardens, Musselburgh.*
May 1926.	‡Sangster, Mrs. Iris, *Fullerswood Park, Mountain Side P.O., Jamaica.*
Feb. 1932.	Scarlett. R. L., C.D.A., *Sweethope, Musselburgh.*
Dec. 1887.	‡Scott, J. S., L.S.A., 69 *Clowes Street, West Gorton, Manchester.*
Mar. 1925.	Smart, Mrs J. P., 279 *Wellesley Road, Methil.*
Dec. 1922.	Smith, Miss Edith Philip, B.A., Ph.D., F.L.S., 46 *Murrayfield Avenue, Edinburgh*, 12.
Nov. 1926.	‡Smith, H. Guthrie, *Tutira, Napier, New Zealand.*
Nov 1914.	*Smith, James L. S , M.A., B.Sc., 29 *Wardie Road, Edinburgh*, 5.
Dec. 1917.	†Smith, J. T., 68 *Tennant Street, Glasgow.*
Oct. 1935.	Smith, Rupert, 38 *Greenhill Gardens, Edinburgh*, 10.
Jan. 1902.	*Smith, Professor Sir Wm. Wright Smith, M.A., *King's Botanist, Regius Keeper, Royal Botanic Garden, Edinburgh*, 4.
Nov. 1923.	†Stern, Frederick, *Highdown, Goring-on-Sea.*
Oct. 1923.	†Stevenson, J. B , *Tower Court, Ascot.*
Dec. 1936.	Stevenson, Miss J. J , 7 *South Trinity Road, Edinburgh*, 5.
Oct 1914.	†Stewart, Edward J. A., M.A., B.Sc., 8 *Manor Road, Jordanhill, Glasgow.*
Feb. 1938.	Stockman, R., M.D., LL.D., *White Lodge, Barnton Avenue, Davidson's Mains, Edinburgh.*
Dec. 1936.	Stoker, Fred, M B., B.S , F.R.C S.E , *The Summit, Loughton, Essex.*
May 1928.	Sutherland, Lady, 11 *Inverleith Row, Edinburgh*, 4.
Jan 1913.	‡Tagg, M H., 53 *Clayton Avenue, Wembley, Middlesex.*
Oct. 1926.	*Taylor, George, D Sc., F.R.S.E., *Dept of Botany, British Museum (Nat Hist), Cromwell Road, London, S W.* 7.
Dec. 1922.	†Taylor, George Crosbie, B Sc., F.L S , 20 *Tavistock Street, Covent Garden, London, W.C.* 2.
Dec. 1923.	†Taylor, James, M A , B.Sc., *High School, Dalbeattie, Kirkcudbrightshire*
May 1923.	†Taylor, R. A., B Sc., Ph D., *Dept. of Botany University College, Dundee*
Oct. 1929.	Terras, Mrs Kate R., 40 *Findhorn Place, Edinburgh*, 9.
Oct. 1932.	Tetley, Miss U., M.Sc., *Quarry Garth, Windermere, Westmoreland.*
April 1921.	†Thompson, Professor J. MacLean, M.A , D Sc., F.L.S., *Dept. of Botany, The University, Liverpool.*
Jan. 1937.	Thomson, John R., B Sc., *School of Agriculture, Khartoum N., Sudan.*
Oct. 1928.	Thomson, Miss Norah M'Nab, 30 *Drumsheugh Gardens, Edinburgh*, 3.
Dec. 1933.	Walton, H. G., C.S.I., *Springfield House, Inveresk.*
Mar. 1932.	Walton, John, M.A , D.Sc., *Professor of Botany, The University, Glasgow.*
Feb. 1939.	Waterston, Mrs M. E., B.Sc., Ph D , 14 *Dundas Street, Edinburgh*, 3.
Oct. 1918.	†Watson, Harry, *Benmore Forest School, Dunoon, Argyll.*
Mar. 1925.	*Watt, James, LL.D., W.S., 28 *Charlotte Square, Edinburgh.* 2.
April 1930.	*Watt, Mrs. Menie, 7 *Blackford Road, Edinburgh*, 10.
Nov. 1921.	*Watt, Miss Janet, 2 *W. Catherine Place, Edinburgh*, 12.
Dec. 1930.	Whyte, James H., B.Sc., *Botany Dept., University of Alberta, Edmonton, Canada.*
Oct. 1935.	Williamson, William, F.R.S.E., F.L.S., 47 *St. Albans Road, Edinburgh*, 9.
Feb. 1912.	*Wilson, Malcolm, D.Sc., *Brentknoll, Kinnear Road, Edinburgh*, 4.
Mar. 1909.	*Wilson, Thos., Ph.C., 110 *High Street, Burntisland.*
Feb. 1938.	Wood, Lt.-Col. J. L., R.A.M C , *Oakwood, Rosslyn Castle, Midlothian.*

Date of Election.

Jan. 1903. Young, William, *Fairview, Kirkcaldy.*
Jan. 1923. *Younger, Harry Geo., *Belhaven House, Dunbar.*

ORDINARY MEMBERS.

Nov. 1933. Anderson. Miss A. B., B.Sc., 24 *Blantyre Terrace, Edinburgh*, 10.
Dec. 1935. Barlow, H. W. B., B.Sc., A.R.S., *Wad Medani, Sudan.*
April 1939. Bostrom, Robert, 12 *Gardiner Grove, Edinburgh*, 4.
Nov. 1932. Broadfoot, Miss J., B.Sc., 17 *Pembridge Square, London, W.* 2.
Dec. 1934. Burnett, Miss J., B.Sc., 2 *Fairfield Road, Inverness.*
Nov. 1932. Callen, Eric O., B.Sc., Ph.D., 9 *Lauderdale Street, Edinburgh*, 10.
Oct. 1937. Campbell, Miss Patricia, B.Sc., 11 *Lynedoch Place, Edinburgh*, 3.
Nov. 1933. Cant, Miss Christine M., B.Sc., Ph.D., *Schoolhouse, Balbardie Road, Bathgate.*
Oct. 1937. Cheeseman, Miss Rosamund, B.Sc., c/o Morrison, 14 *W. Preston Street, Edinburgh*, 8.
Oct. 1936. Chisholm, Mrs., 4 *Wardie Road, Edinburgh*, 5.
Dec. 1938. Crockart, Ian B., B Sc., 17 *Riverside Drive, Stirling.*
Oct. 1931. Cunningham, Miss Mern, 20 *Charlotte Square, Edinburgh*, 2.
Dec. 1935. Dall, Mrs S. I., 2 *Hampton Terrace, Edinburgh*, 12.
Nov. 1926. Drysdale, Miss D., *Royal Botanic Garden, Edinburgh*, 4.
Nov. 1927. Evans. Miss, 38 *Morningside Park, Edinburgh*, 10.
Jan. 1937. Gray, Miss Elizabeth, 18 *House o' Hill Gardens, Edinburgh*, 4.
Nov. 1922. Gregor, Mrs Mary J. F., B.Sc., Ph.D., *North Clermiston House, Barnton, Mid-Lothian.*
Dec. 1937. Handyside, Wm., 53 *Viewforth, Edinburgh*, 10.
Nov. 1932. Hawkins, Miss K , B.Sc., 20 *Charlotte Square, Edinburgh*, 2.
Oct. 1935. Johnstone, R. H., M A., 726 *Anniesland Road, Scotstounhill, Glasgow.*
Dec. 1936. Kennedy, Miss Margaret C. L. S., B.Sc., 384 *Ferry Road, Edinburgh*, 5.
Nov. 1933. Kinghorn, William O., B.Sc., *Morningbank, Duns.*
Oct. 1932. Latham, Mrs. C. A., 27 *Oxgangs Road, Lothianburn, Edinburgh.*
Nov. 1931. Lyall, Charles A., B.Sc., *Ulva House, Bunessan, Isle of Mull.*
April 1925. M'Ilvenna, Wm. R., 14 *Inverleith Place, Edinburgh*, 4.
Dec. 1936. Macleod, Miss Anna M., B.Sc., 3 *Riselaw Road, Edinburgh*, 10.
Nov. 1931. Murray, Charles, B.Sc., 58 *Dunnikier Road, Kirkcaldy.*
Nov. 1928. Murray, John, B.Sc., *Whitslade, Broughton, Peeblesshire.*
Oct. 1932. Noble, Miss Mary, B.Sc., Ph D., 19A *Willowbrae Avenue, Edinburgh*, 8.
Nov. 1931. Orr, Harry R., B.Sc., Ph.D , *The Technical College, Derby.*
Mar. 1935. Parker, W. A , D.S.O., J.P., M.Inst.C.E , 10 *Dean Park Crescent, Edinburgh*, 4.
April 1930. Robson. Thomas 6 *Kirkhill Road, Edinburgh*, 9.
Nov. 1931. Shearer, Miss Winifred, B.Sc., 60 *Fern Grove, Sefton Park, Liverpool*, 8.
Nov. 1932. Sinclair, James, B.Sc., c/o Mrs Dennison, *Ellerslie, Stronsay, Orkney.*
Nov. 1931. Sloan, Miss Evelyn Betty V., B.Sc., 29 *Regent Terrace, Edinburgh*, 7
Nov. 1926. Smith, Miss M. H., B.Sc., *Inverleith House, Edinburgh*, 4.
April 1925. Smith, Thomas Arthur, 39 *Restalrig Road, Edinburgh*, 6.
Dec. 1936. Stephens, S. G., M.A., *Cotton Research Station, St. Augustine, Trinidad, B.W.I.*
Dec. 1930. Torbock, H. C., *Crossing Hall, Cliburn, Penrith.*
Jan. 1937. Torrance, Miss Margaret, 10 *Hermitage Drive, Edinburgh*, 10.
Dec. 1923. Wallace, G. B., B Sc., Ph.D., 19 *Joppa Road, Portobello, Edinburgh.*
Dec. 1936. Waterston, Miss Elspeth J., B.Sc., 113 *Marchmont Road, Edinburgh*, 10.
Nov. 1931. Waterston, John M., B.Sc., 113 *Marchmont Road, Edinburgh*, 10.
Nov. 1932. Watson, E. V., B.Sc., Ph.D., *Lynnholm, Wardie Crescent, Edinburgh*, 5

ASSOCIATE.

Jan. 1906. Harrow, R. L., *Director, Royal Horticultural Society's Gardens, Wisley, Ripley, Surrey.*

LADY MEMBERS.

Date of Election.	
June 1893.	Aitken, Mrs. A. P., 15 *Victoria Mansions, West Hampstead, London, N.W.*
April 1893.	Balfour, Lady Bayley, *Penfold's Corner, Haslemere, Surrey.*
Dec. 1926.	Callender, Mrs. C. A., 31 *Inverleith Terrace, Edinburgh*, 4.
May 1936.	Cowan, Mrs., B.A., 17 *Inverleith Place, Edinburgh*, 4.
Feb. 1937.	Fenton, Mrs Wyllie, 16 *Wilton Road, Edinburgh*, 9.
May 1936.	Fleming, Miss Harriet, M.A., 30 *Royal Circus, Edinburgh*, 3.
Feb. 1910.	Galletly, Mrs. Sarah H., 32 *Mansionhouse Road, Edinburgh*, 9.
Oct. 1936.	Groves, Mrs. Anne M., 44 *Beauchamp Road, Liberton, Edinburgh*, 9.
Oct. 1936.	Gumley, Lady, 52 *Inverleith Row, Edinburgh*, 4.
Feb. 1933.	Hogg, Miss Elizabeth M., 14 *South Learmonth Gardens, Edinburgh*, 4.
Oct. 1937.	Miller, Mrs Hugh, 22 *Blacket Place, Edinburgh*, 9.
Nov. 1926.	Smith, Lady, *Inverleith House, Edinburgh*, 4.

CORRESPONDING MEMBER.

Dec. 1905.	Mattirolo, Professor O., *R. Istituto Botanico, Torino* (120) *Italy.*

THE SOCIETY EXCHANGES PUBLICATIONS WITH—

EUROPE.

GREAT BRITAIN AND IRELAND.

Aberystwyth, . . . Welsh Plant Breeding Station.
Belfast, ... Natural History and Philosophical Society.
Berwick, ... Berwickshire Naturalists' Club.
Bristol, ... Bristol Naturalists' Society.
Cambridge, . . . Philosophical Society.
Cardiff, ... Naturalists' Society.
Dublin, ... Royal Dublin Society.
Dumfries, . . . Dumfriesshire and Galloway Natural History Society.
East Malling, . . East Malling Research Station.
Edinburgh, . . . Edinburgh Geological Society.
Royal Scottish Forestry Society.
Royal Scottish Geographical Society.
Royal Scottish Society of Arts.
Royal Society of Edinburgh.
University of Edinburgh.
Glasgow, ... Glasgow and Andersonian Natural History Society.
Royal Philosophical Society.
University of Glasgow.
Hull, ... Yorkshire Naturalists' Union.
Leeds, ... University of Leeds.
Liverpool, . . . Hartley Botanical Laboratories.
London, ... Linnean Society.
Ministry of Agriculture.
Quekett Microscopical Club.
Royal Botanic Gardens, Kew.
Royal Horticultural Society.
Royal Microscopical Society.
Royal Society.
Science Library, South Kensington.
Essex Field Club.
Hertfordshire Natural History Society and Field Club.
Manchester, . . Manchester Literary and Philosophical Society.
Millport, . . . Scottish Marine Biological Association.
Newcastle-upon-Tyne, . Editor of *The Vasculum*.
Natural History Society of Northumberland, Durham, and Newcastle-on-Tyne.
University of Durham Philosophical Society.
Norwich, . . . Norfolk and Norwich Naturalists' Society.
Perth, ... Perthshire Society of Natural Science.
Plymouth, . . . Plymouth Institution
Wye, ... Horticultural Education Association.

BELGIUM.

Brussels, . . . Académie Royale de Belgique.
Institut Botanique Léo Errera.
Société Royale de Botanique de Belgique.
Liége, ... Institut de Botanique.

BULGARIA.

Sofia, ... Société Botanique de Bulgarie.

DENMARK.

Copenhagen, . . Botanisk Haves Bibliothek.
Dansk Botanisk Forening.
Disko, Greenland, . Den Danske Arktiske Station.
Lyngby, ... Statens plantepatologiske Forsög.

FINLAND.

Helsingfors, . . . Societas pro Fauna et Flora Fennica.
Societas Zoolog-Botanica Fennica Vanamo.
Society of Forestry in Finland.

FRANCE.

Amiens, ... Société Linnéenne du Nord de la France.
Cherbourg, . . . Société Nationale des Sciences Naturelles.
Lyons, ... Société Linnéenne de Lyon (Section Botanique).
Marseille, . . . Faculté des Sciences de Marseille.
Paris, ... Société Botanique de France.
Toulouse, . . . Société d'Histoire naturelle.
Versailles, . . . Station Centrale de Pathologie Végétale.

HOLLAND.

Amsterdam, . . . Botanical Society of Holland.
Koloniaal Instituut.
Koninklijke Akademie van Wetenschappen.
Haarlem, . . . Musée Teyler.
Leiden, . . . Rijks Herbarium.
Utrecht, ... Botanical Museum and Herbarium of the University.
Wageningen, . . . State Agricultural Library.

HUNGARY.

Budapest, . . . Hungarian Association of Natural Sciences.
University Botanic Gardens.

ITALY.

Bologna, ... Editor of *Malpighia*.
Florence, . . . Societa Botanica Italiana.
Rome, ... International Institute of Agriculture.
Regio Istituto Botanico.
Cagliari, Sardinia, Istituto Botanico, R. Universita.

LITHUANIA.

Kaunas, ... Mat-gamtos fakulteto Darbai Universitetas.

LUXEMBOURG.

Luxembourg, . . . Société des Naturalistes Luxembourgeois.

NORWAY.

Oslo, ... Botanic Garden.
Tromso, ... Tromso Museum.

PORTUGAL.

Coimbra, . . . Instituto Botanico, Universidade.
Lisbon, ... Academia das Sciencias.

RUSSIA.

Baku, ... Institute Botanique.
Kiew, ... Academie des Sciences d'Ukraine.
The State University of Kiew.
Leningrad, . . . Botanical Institute of the Academy of Sciences.
Institute of Plant Industry.
Moscow, ... Société des Naturalistes de Moscou.
Tashkent, . . . First Central Asiatic University.
Tiflis, ... Botanic Institute.

SWEDEN.

Gothenburg,	Goteborgs Botaniska Tradgard.
Lund,	Universitas Lundensis.
Stockholm,	Kungl. Svenska Vetenskaps Akademien.
	Svenska Botaniska Föreningen.
Upsala,	Kungl. Vetenskaps Societeten.
	Botaniska Institutionen.

SWITZERLAND.

Berne,	Naturforschende Gesellschaft.
Geneva,	Conservatoire et Jardin Botaniques.
	Institut Botanique, Herbier Boissier.
Zurich,	Naturforschende Gesellschaft.

YUGOSLAVIA.

Belgrade,	Academie Royale Serbe.

AFRICA.

Cairo,	Faculty of Science, Egyptian University.
Cape Town,	South African Museum.
Ibadan,	The Nigerian Field Society.

ASIA.

Calcutta,	Royal Botanic Garden.
	National Institute of Sciences of India.
Dehra Dun,	Forest Research Institute.
New Delhi,	Agricultural Research Institute.
Peradeniya,	Royal Botanic Gardens.
Singapore,	Botanic Gardens.
Manila,	Department of Agriculture and Commerce.
Buitenzorg,	Departement van Landbouw, Nijverheid en Handel.
Formosa,	Department of Forestry, Government Research Institute, Taihoku Imperial University.
Kurashiki,	Ohara Institute for Agricultural Research.
Sapporo,	Sapporo Natural History Society.
Sendai,	Biological Institute, Tohoku Imperial University.
Tokio,	College of Agriculture, Imperial University.
Peiping,	National Tsing Hua University.
Shanghai,	Science Society of China.

AUSTRALASIA.

Brisbane,	Department of Agriculture.
	Royal Society of Queensland.
Hobart,	Royal Society of Tasmania.
Launceston,	Department of Agriculture, Tasmania.
Melbourne,	Botanical Department, University of Melbourne.
	National Herbarium.
	Royal Society of Victoria.
Sydney,	Fisher Library, Sydney University.
	Linnean Society of New South Wales.
	Royal Society of New South Wales.
Wellington,	Royal Society of New Zealand.

AMERICA.

CANADA.

Halifax,	Nova Scotian Institute of Science.
Montreal,	McGill University.

Ottawa, ...	Canadian Forestry Association.
	Central Experimental Farms.
	Department of Agriculture.
	Department of the Interior, Forestry Branch.
	Geological Survey of Canada.
Toronto, . . .	Royal Canadian Institute.

SOUTH AMERICA.

Buenos Aires, . .	Museo Naçional de Historia Natural.
La Plata, . . .	Museo de La Plata.
Tucuman, . . .	Instituto Miguel Lillo.
Rio de Janeiro, .	Instituto de Biologia Vegetal.
	Museu Naçional.
San Paulo, . .	Secção de Botanica e Agronomica.
Bogota, ...	Ministry of Public Works.
Monte Video, . .	Museo Naçional.

UNITED STATES.

Ames, Iowa, . .	Iowa State College.
Ann Arbor, Mich.,	Michigan Academy.
Berkeley, Cal., .	University of California.
Los Angeles, Cal.,	University of California at Los Angeles.
Boston, Mass., .	Society of Natural History.
Brooklyn, N.Y., .	Brooklyn Botanic Garden.
Cambridge, Mass.,	Gray Herbarium, Harvard University.
Cincinnati, O., .	Lloyd Botanical Library.
	Society of Natural History.
Colorado Springs, Col.,	Coburn Library.
Columbia, Mo., .	University of Missouri.
Columbus, O., .	Ohio State University.
Geneva, N.Y., . .	Agricultural Experiment Station.
Indianapolis, Ind.,	Indiana Academy of Sciences.
Ithaca, N.Y., . .	New York State College of Agriculture.
Jamaica Plain, Mass.,	Arnold Arboretum.
La Fayette, Ind., .	Purdue University Agricultural Experiment Station.
Lawrence, Kan., .	Kansas Academy of Science.
Madison, Wis., .	Agricultural Experiment Station.
	Wisconsin Academy of Sciences.
Manhattan, Kan.,	State Agricultural College.
Milwaukee, Wis., .	Public Museum.
Minneapolis, Minn.,	Botanical Department, University of Minnesota.
Morgantown, W. Va.,	Southern Appalachian Botanical Club.
New Haven, Conn.,	Connecticut Academy of Arts and Sciences.
New Orleans, La.,	Southern Forest Experiment Station.
New York, N.Y.,	New York Academy of Sciences.
	New York Botanical Garden.
	Torrey Botanical Club.
Philadelphia, Pa.,	Academy of Natural Sciences.
	American Philosophical Society.
	University of Pennsylvania.
Pullman, Wash., .	State College of Washington.
Rochester, N.Y., .	Rochester Academy of Sciences.
St. Louis, Mo., .	Missouri Botanical Garden.
San Francisco, Cal.,	California Academy of Sciences.

Syracuse, N.Y., . New York State College of Forestry.
Urbana, Ill., . . University of Illinois.
Washington, D.C., National Academy of Sciences.
Smithsonian Institution.
United States Department of Agriculture; Forest Service; National Museum; Office of Experiment Stations.
Woods Hole, Mass., Marine Biological Laboratory.

WEST INDIES.

Jamaica, . . . Department of Agriculture.
Trinidad, . . . Royal Botanic Garden.

INDEX.

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